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PRODUCTIVITY

Special Section

Plant Engineering

PLANT ENGINEERING PRACTICES
MANAGEMENT OF UTILITIES
OPERATIONAL PROBLEMS
METAL INSPECTION
MAINTENANCE

INDUSTRIAL SAFETY
PRODUCTIVITY AGREEMENTS
PRODUCTIVITY SHARING
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TRADE UNIONS & PRODUCTIVITY

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NATIONAL PRODUCTIVITY COUNCIL

The National Productivity Council is an autonomous organisation registered as a Society. It is tripartite in its constitution and representatives of Government, employers, workers and various other interests participate in its working. Established in 1958, the Council conducts its activities in collaboration with institutions and organisations interested in the Productivity Drive. Besides its headquarters at New Delhi, NPC operates through six Regional Directorates. Its activities are further extended by a nation-wide network of forty-six Local Productivity Councils.

The purpose of NPC is to stimulate productivity consciousness in the country and to provide service with a view to maximising the utilisation of available resources of men, machines, materials and power; to wage war against waste; and to help secure for the people of the country a better and higher standard of living. To this end, NPC collects and disseminates information about techniques and procedures of productivity. In collaboration with Local Productivity Councils and various institutions and organisations, it organises and conducts training programmes for various levels of Management in the subjects of productivity. It has also organised an advisory service for industries to facilitate the introduction of productivity techniques.

Recognising that for a more intensive productivity effort, the training and other activities of NPC, designed to acquaint management with productivity techniques, should be supported by demonstration of their validity and value in application, NPC offers a Productivity Survey and Implementation Service (PSIS) to industry. The demand for this service has been rapidly growing. This Service is intended to assist industry adopt techniques of higher management and operational efficiency consistent with the economic and social aspirations of the community. PSIS is a highly competent consultancy service concerned with the investigation of management and operational practices and problems, and recommendation of measures of improvement and their implementation. NPC has established a special Fuel Efficiency Service. It has set up cells for servicing small scale industries. It has introduced a National Scheme of Supervisory Development under which an examination is held and certificates awarded to successful candidates. NPC also conducts a two-year practice-oriented programme for training in Industrial Engineering for first class graduates in Engineering disciplines.

NPC publications include pamphlets, manuals and Reports of Productivity Teams. NPC utilises audio-visual media of films, radio, and exhibitions for propagating the concept and techniques of productivity. Through these media NPC seeks to carry the message of productivity and create the appropriate climate for increasing national productivity.

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ditor : V.K. Goel

PRODUCTIVITY

CONTENTS

			Page
I SPECIAL SECTION : PLANT ENGINEERING			
Utilities and Plant Equipment Practices	...	*T.S. Festus*	5
Planned Maintenance—An Essential for Production Management	...	*Late Shantilal J. Jain*	14
Evaluation of the Effectiveness of Maintenance	...	*K. Ramesam*	25
Management of Utilities	...	*S. Govindarajan*	43
Overcoming Hazards in Chemical Industries	...	*A.K. Pratap Singh*	52
Operational Problems in Fertiliser Industry	...	*P.L. Kukreja*	60
Metal Inspection in Fertiliser Plant Maintenance	...	*S.R. Ramchandran*	65
Technical Aspects of Industrial Safety	...	*K. Kumar*	76
Industrial Safety Needs Organisation and Planning	...	*D.M. Patel*	83
Plant Engineering Service—A Modest Beginning in N.P.C.	...	*S. Ghosh*	89
BOOK REVIEWS			95

III SUPPLEMENT : SEMINAR ON SHARING THE GAINS OF PRODUCTIVITY

Inaugural Address	...		3
Keynote Address by Chairman	...		6
Summary of Proceedings	...		8
Concept of Productivity Agreement	...	*P.N. Krishna Pillai*	12
Rationale of Productivity Agreements	...	*S.K. Warriar*	18
Raising the Productivity and Sharing its Gains	...	*S.K. Maini*	29
Models for Sharing the Gains of Productivity	...	*R.S. Gupta*	38
Distribution of Productivity Gains	...	*M.M. Jacob*	41
Productivity Agreement—A Trade Union Point of View	...	*S.C.S. Menon*	45
Productivity Incentive Scheme in Hindustan Insecticides Ltd.	...	*T.A. George*	57
Pre-requisites for Sharing the Gains of Productivity	...	*K.P. Sachindranath*	67
Productivity Agreement—A Case Study	...	*R. Baktha*	73
Here, the Advertisers	...		106

PRODUCTIVITY

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NPC Plant Engineering Services

PROMOTION of productivity in all areas of economic activity has been the prime objective of the National Productivity Council and, in fact, the *raison d'etre* of its existence. For the achievement of the above-stated goal, the NPC, over the years, has gradually developed variety of techno-managerial services to assist the industry in the persuit of optimum utilisation of three M's—MAN, MACHINE, MATERIAL. Training and consultancy services in the traditional fields of Industrial Engineering, Industrial Management and Industrial Relations have already reached their age of maturity, catering to the varied needs of the industry for more than a decade now. With the spate of technological development there has, however, been a growing demand for technological services in such special fields as the Fuel Efficiency, Production Engineering and Plant Engineering. Accordingly, the NPC has recently created a new Division called Fuel Efficiency and Technological Services Division to serve effectively the changing needs of the industry, by providing comprehensive training programme and consultancy services in the field of fuel efficiency, production engineering and plant engineering.

Plant Engineering in its broadest sense can be defined as a special branch of engineering which deals with industrial plants and machineries. Thus it includes not only maintenance, repairs and renewals but also includes other related areas such as corrosion, instrumentation and plant protection.

NPC proposes to adopt a three-dimensional approach in this field. It offers consultancy services in specific areas such as Trouble-shooting, Vibration Analysis and Control, Maintenance Systems etc. It offers specialised training courses in Plant Maintenance, Standardization, Testing and Inspection, etc. It intends to build documentation service in this vital area and prepare a list of specialists and talents in the field.

NPC cannot succeed in this bold venture until it gets cooperation from the practising Plant Engineers. With this end in view and for popularising this new concept of Engineering, we are bringing out this special issue. We would welcome our readers, reactions in this regard.

Utilities and Plant Equipment Practices

T.S. Festus*

Plant engineering, in its broadest sense, could be defined as a special branch of engineering which deals with conversion of capital into industrial assets such as machinery, plant and equipments as also their proper maintenance for the continued production of goods and services. Before Independence, the plant engineering or utilities and plant equipment practices were at rudimentary level as the industrialisation was itself in its nascent stage. After Independence, though efforts were made to develop this branch of knowledge, they were marked by heavy reliance on foreign technology. One of the biggest challenges that confront the Indian industry is to develop the plant engineering practices indigenously without which the goal to achieve a self-sustained industrial growth would continue to remain a far cry. The time is now, if ever, to make a sincere and concerted effort in this direction.

PLANT Engineering can be defined as the branch of engineering knowledge which deals in converting capital into industrial assets such as buildings, structures, machinery, plants and equipments, and maintaining them for the continued production of goods and services. Such productive assets of an industrial undertaking and their systematic care, upkeep and maintenance can be called "Utilities and Plant Equipment Practices". In short, plant engineering deals with utilities, plants and equipments.

The type of "Utilities" and the types of "Plant Equipments" needed for any industry will depend upon the nature of the industry itself. Therefore a study of utilities and plant equipment practices has to be made against industries falling under a particular group. To began with, let us examine in detail the types of utilities and plant equipments that have been in use in the past, and are being used at present by various groups of industries to convert traditional inputs into useful products and services.

Before Independence, during the 150 years of British rule, we did not have a proper climate for the development of any broad-based industrial structure in India. All we had were Tea-Factories, Rubber Factories, Match Factories, Sugar Factories, Textile, Jute and Paper Mills, Thermal and Hydro-Electric Power Generating Stations, Coal Mines, Iron Ore and Manganese Ore Mines, Maintenance and Repair Workshops for Railways and the

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Defence Equipments of the British Army, Navy and Air Force. These industries, which were set up for the convenience of the ruling power utilised foreign technology, know-how, and plant engineering services. Hence, we did not have any opportunity to develop the main and creative part of plant engineering activities, during pre-independance period, namely design, procurement, construction, fabrication and erection.

Practices Before Independence

What then were the plant engineering practices, prevalent in the industries of the pre-independence days ? In the Agro-Industries, plant engineering was merely concerned with operating and maintaining the utilities, including power plants and maintaining the manufacturing machinery. For example, in a small Tea-factory, plant engineering duties were performed by a mechanic, who is responsible for running and maintaining a gas or diesel engine, a dynamo or an alternator driven off the gas-engine-driven shaft, a cooling spray pond for engine cooling ; and generally maintaining the tea-manufacturing machines and perhaps running a carpentry workshop for making tea-chests for packing of tea. For major overhaul of plant and equipments, providing additional utilities and for modification or expansion of the manufacturing process the services of outside experts, usually the engine and machinery manufacturers' service engineers and mechanics were utilised, who in turn made use of the services of outside fabrication and repair shop as required.

In sugar and alcohol industries "Utilities and Plant Equipments" were looked after by mechanical and electrical engineers. The duties consisted of running and maintaining power plants, such as steam boilers, steam engines, turbo-alternators and plant equipments such as cooling towers or spray ponds, cane handling, cutting and crushing machinery and equipment ; also maintaining and repairing sugar manufacturing machinery, sugar handling and bagging machinery. Besides the utilities and plant equipment maintenance, the plant engineering department may run a foundry, a machine shop and fabrication shop. Further, it will not be uncommon to run a repair shop for tractors, lorries, jeep, cars etc.

In old cotton spinning mills and weaving factories, the responsibilities of the plant engineering department were : running the utilities similar to the sugar factories and carrying out repairs and maintenance to them and also arranging repairs, and maintenance to the preparing and spinning machinery, weaving machinery, dyeing plant, finishing calanders, baling presses etc.

The transport and shipping industries, mainly consisted of the railways and shipping lines. Here the main emphasis was on operating and maintaining railway engines and shops, as well as constructing and maintaining railway tracks. dockyards and ship-repairing facilities.

In public utilities such as thermal power plants and hydro-electric plants, the function of plant engineering is operation and maintenance of plants, such as high-pressure steam boilers, steam turbines, water turbines, coal conveyors, pulverisers, blowers, fans, water treatment plants, pumps, heat-exchangers, condensers, de-aerators, alternators, transformers switch gears, distribution cables, sub-station etc. Unlike other industries, where plant engineering and production engineering are generally functioning under separate departmental managers, power stations are generally organised as one unit, even though a separate section may be functioning to look after maintenance. This enables most of the operating personnel to do their own day to day maintenance and maintenance personnel to concentrate on more specialised work, such as major repairs, annual overhauls, alterations and additions to plant and equipments to improve efficiency, and reduce frequency of maintenance etc. This system has the advantage of increased efficiency of operation and maintenance with reduced manpower requirement. The twin function of plant engineering and operation engineering is collectively called as power plant engineering. Most of our successful present-day plant engineers of modern complex chemical and metallurgical processing plants have started their career as power-plant engineers having both operational and maintenance experience of steam plants, refrigerating plants, liquid pumps, compressors, blowers, vacuum pumps, generators, condensers, heat-exchangers, switch gears, distribution channels, transformers, electric motors, automatic controlling instruments etc.

In engineering fabrication and repair workshops, which were all we had by way of engineering industries in the pre-independence days, the plant engineering and production engineering functions were usually merged, although it is not the case in modern mass-production engineering industries, about which we shall discuss later. These industries were insufficient to statisfy the demand for consumer goods even during the colonial days and the bulk of our consumer goods had to be imported.

After Independence

After independence, our National leaders, particularly Jawaharlal Nehru, felt the need of rapid industrialisation of India to bring about technological and economic independence; and many sophisticated industries were planned and started all over India during the post-independence Five-Year Plans.

These industries could be grouped under the following heads :

1. Mining
2. Iron & Steel Industries
3. Non-ferrous Metallurgical Industries
4. Alloy Steel Industries
5. Chemical & Pharmaceutical Industries
6. Fertiliser Industries
7. Petroleum Refining & Petrochemical Industries
8. Synthetic Fibre & Plastic Industries
9. Pigment & Dye-Stuff Industries
10. Food Processing Industries
11. Engineering, Machine Building, Power Plant & Equipment Building Industries
12. Civil Construction Industries
13. Transport & Communication Industries
14. Service Industries
15. Defence-Oriented Industries
16. Nuclear Power Industries and
17. Other Industries

Foreign Technology

These industries have accounted for the bulk of our capital expenditure during the past 3 Five-Year Plans and the current 4th Five-Year Plan, and have been sponsored by the public, private and joint sectors. If we look back at the history of development of plant engineering practices of various industries, under the above group, set up after independence, it will be seen that almost all industries have made use of foreign technology, on a turn key basis. No doubt, in a developing country like ours, it will not be possible for us to develop technology and know-how overnight and dispense with foreign technical assistance entirely. Side by side with our plans to set up sophisticated industries we had set up national laboratories to carry out fundamental research, and industrial research institute for carrying out applied research, staffed with the best available scientists in our country. We also had experienced plant engineers, production engineers, civil and structural engineers and electrical engineers who have associated themselves with whatever industrial activity we have had. But we have failed to fully utilise these available talents in building up our industrial complexes due to lack of knowledge and foresight on the part of our entrepreneurs, both private and public.

It will serve no useful purpose here, to recapitulate how this inadvertant underutilisation of available human resources could have been avoided. However, it is common knowledge that private sector industries have been started, by trading firms in imported goods when the ban on imports was progressively tightened by the government; and one cannot blame them entirely if they invited their foreign principals to collaborate and transfer their know-how and start industries for them in India on turn-key basis on terms which were never intended to be grasped and absorbed successfully by the available technical personnel in India. Even the public sector industries which were established by our civil servants, on turn-key basis had collaboration agreements harmful to national interests. Public sector bureaucrats with little knowledge of world market trends and technological developments in plant and production Engineering could not, in many cases, select the right type of technology and purchase the plant and know-how, on suitable terms, nor were they capable of selecting the right type of plant engineering and process engineering personnel and associating them with new industries right from the negotiating stage with regard to transfer of know-how and technology. Had these aspects been realised from the beginning of our industrialisation all our Industries would have turned the corner in about five years' time since Independence, and, by now, we would have developed a self-sustaining industrial base supporting an integrated industrial research and development setup, in all important groups of industries. Along with it our plant engineering practices would have been fully developed in each and every major industry, capable of building up more and more industrial plants using more and more indigenously developed processes relying less and less on foreign technology and know-how.

Self-Reliance — An Imperative

We cannot afford to make this mistake any more. As it is, plant engineers have to cover a lot of ground and equip themselves fully for the successful completion of Fifth Plan targets. It is estimated that Rs. 50,000 crores will be spent on industries and social services during the fifth plan period. This huge capital will have to be converted into industrial assets, for the production of goods and services. There cannot be greater challenge for plant engineers and plant engineering than this.

What should be done to meet the challenge of the coming years ? Our plant engineering knowledge and skill which have been static for a considerable period will not grow up to its full stature if the present methods of setting up industries are not changed.

Entrepreneurs and public sector industries should ponder over the past mistakes and set up industries with a good mix of foreign and indigenous know-how on terms which would give full scope for indigenous research and development as well as fuller utilisation of indigenous plant engineering practices for further progress.

With a view to bring before our industrialists, whether in the public sector or in the private sector, the prime importance of plant engineering and the need for its development to help establish self-reliance and build-up viable industrial plants in the future, we need to strengthen the weak links in certain branch of plant engineering in certain group of industries, particularly, plant equipment practices, in chemical processing industries. Also industrial organisation should be reviewed with a view to produce indigeneous know-how and make use of indigenously designed utilities and plant and equipments. At the same time industries should ensure that where foreign know-how is indispensable it should be obtained on proper terms which would ensure a further step towards self-sufficiency. This will certainly involve plant engineering and process engineering from the very start of any new industrial plant, and result in healthy growth of industries. It is indeed timely that the National Productivity Council should think it proper, to start a section in their journal, to spread the importance of plant engineering to the industries and its inter-relationship with other activities of industrial plants.

To achieve this important task, the following functional aspects as well as organisational aspects of plant engineering are fully discussed and suggestions made for the benefit of industrialists as well as the professional plant engineers to improve upon plant engineering practices before we enter into the Fifth Plan period.

Plant Engineering Knowledge

The most important function of plant engineering should be to make sure that plant engineering personnel at all levels possess adequate knowledge on utilities and "Plant Equipments". The critical and capital-intensive equipments of the utilities are power plants, whether steam-driven engine, or steam-driven generator or both, supplying mechanical and electrical power required for the running of any industry. The economy of production in any plant depends upon the economy at which the power is generated whether mechanical power or electrical power, although modern power plants have built-in automation to ensure optimum fuel economy. This means that plant engineering knowledge should be adequate to ensure that automatic controls are correctly set and operated to maintain fuel economy at all times. Besides, because of costs, power plants are not duplicated and hence reduction in speed or prolonged breakdowns of power plants will affect the production of all sections of the plant. Hence the operation and maintenance of utilities received the maximum attention, even during the pre-independence days. Since plant engineers have been operating and maintaining the utilities for a considerable time beginning from the pre-independence days, this branch of plant engineering has been well developed in our country and we have gained considerable expertise in this field. We have ample training facilities for engineers, foremen, supervisors, operating and maintenance technicians of power plant and other utilities generally used in all sophisticated industrial undertakings. We have courses leading to Mining Engineer's

Certificates, Boiler Proficiency Certificates, Boiler Attender's Certificates, Electrical Supervisor's Certificates, Electrician's and Wiremen's Certificates etc. Besides this there are very comprehensive training courses of a very advanced nature available for engineers and technicians of the Navy and Mercantile Marine on the operation and maintenance of steam and diesel power plants and their various auxiliaries and electronic gadgets for automatic weapon control.

Further, India is fast becoming self sufficient in the indigenous manufacture of the various plants and equipments required for industrial utilities, and most of them have been standardised, making it possible for the rapid spread of utilities knowledge among the plant engineers.

Almost all groups of industries make use of similar type of utilities. But the distribution of various types of utilities may differ from plant to plant. In modern mass-production engineering plants the tool room service is the most important aspect of plant engineering. In olden type of repair workshops and jobbing type of engineering production shops, tooling requirements were looked after by the production engineers themselves and as mentioned earlier there was no separate plant engineering department. But modern engineering plants have a well-organised plant engineering department which looks after construction, erection and maintenance of plants, machine-tools and utilities. Also the tooling responsibilities are entrusted to the plant engineering department. Modern mass production, metal and plastic industries depend on well-designed tools for their mass production of quality goods. The knowledge and skill of tool making in our country is inadequate. to cope up with our future demands and this field will have to be strengthened. Also the alloy steel industry will have to be developed to enable the industry to produce the necessary alloy steels required for tool making. It is hoped that the National Productivity Council would strive to solve this problem with the active cooperation of experienced practising plant engineers.

Changing Needs

In the pre-independence days, the industries were less complicated and most of them used conversion technology for their manufacturing processes. For example cotton and jute fibres were converted into yarn and fabrics. Sugarcane juice was converted into sugar crystals, rubber latex into sheets, tea-leaves into tea, wood fibres into paper, boards etc. No doubt chemicals were used in some of the manufacturing processes ; but they are in the nature of cleaning or purifying agents and the chemicals used are generally recovered and re-used. Further, the manufacturing was done in individual machines like spinning machine, weaving machine, paper-making machine etc. So the plant equipments used are less complicated and capable of being maintained with less sophisticated knowledge. Most of the machines are similar and could be easily maintained, one or a few at a time, without affecting production of other machines. Seasonal industries could carry out their plant maintenance during off seasons. So, plant equipments posed no problem to maintenance engineeers and in spite of lack of systematic maintenance procedures and each maintenance engineer choosing his own system of maintenance, the results achieved have always been good and one never dared blame maintenance for lack of production with justifiable reasons. Further, it was always easy to find out the real reasons for loss of production.

In modren industrial plants, using chemical processes and catalytic reactions using acids, alkalies and a variety of solvents and reactive chemicals and using a wide variety of materials of construction to withstand corrosion, erosion, high temperatures, high pressures, low temperatures etc ; utilising plant equipments ranging from simple centrifugal pumps to complicated high-speed centrifugal compressors, from simple reciprocating dosing pumps to giant multi-stage reciprocating compressors, packed columns, heat exchangers, pressure vessels etc., it is difficult to comprehend the variety and range of plants and equipments used. Further, most of such plants use single stream, automatically controlled continuous process, needing a wide knowledge of plant equipments and high degree of operational and maintenance skill and competence which are lacking even today.

Coordination—Need of the Hour

Maintenance of such an impressive array of heterogenous equipments needs the coordinated efforts, not only of the maintenance engineers but also of the production engineers and top management for the following reasons:

1. Maintenance is affected by the operational procedures.
2. Maintenance is affected by the choice of technology and equipments and utilities.
3. Maintenance is affected by the production plans if formulated without the knowledge of maintenance personnel.
4. Plant and equipment life is affected by the upset in operational parameters or the parmeters going beyond the limits of equipment capability, materials of construction etc.
5. Plants are affected by the use of substandard raw materials, processing water and chemicals.
6. Equipments getting affected and damaged due to scale forming and choking of pipe-lines, vessels etc.

Thus, it could be seen, that maintenance of plants and equipments have become very important and requires more organised efforts than before, and the failures of industrial plants which we are witnessing all around are mainly due to lack of adequate knowledge at top level and organisational effectiveness in industrial plants to tackle maintenance problems, rather than inadequate maintenance and maintenance personnel. This state of affairs will have to be set right.

Project Engineering : is that part of plant engineering which deals with the design and construction of plants including selection and fabrication of equipments and plant layout. Project engineering is essentially team work of various engineering disciplines such as mechanical engineering, civil engineering, electrical engineering, instrumentation engineering and chemical engineering. Industrial Plants which were set up by foreign collaboration, have their project work carried out by foreign construction firms with Indian plants and production engineers standing by with little participation. In some cases the plant's blueprints and detailed equipment drawings with full specification, materials of construction etc. were never handed over to the Indian plant engineers even though the technology transferred had become obsolete in the donor country. Plant engineering aspects will have to be fully developed by us, before the Fifth Plan period, if we have to make full use of the technology and processes that are likely to be developed in India. It appears that government policy will be towards self-sufficiency in technology and process development by Indian scientists and technologists. This means that we may expect the growth of Research and Development in most of our industries and the plant engineering responsibilities will be increased to the extent of constructing and setting up pilot plants and full-scale commercial plants. This trend has already been started and is expected to grow at rapid pace, and we should be careful in developing the right type of project engineering organisation with team work rather than individual work. PERT/CPM network analysis should be increasingly used for monitoring projects in every industry even though the uncertainties are too many in India due to steel and cement shortage, bad delivery schedules of heavy equipment fabricators due to raw material shortages, power shortages and bad industrial relations and short-sighted Government-Labour policies in some States with an eye on election at the expense of production.

Preventive Maintenance : The current knowledge and the preventive maintenance methods that have been advocated by various training bodies in India are totally outdated. It appears that these methods were in vogue during the days of textile mills, cement and paper mills and these are not adequate for modern complex single stream and fully automatic process industries. Further it may be a revealing experience, how little is known about preventive maintenance even among maintenance engineers and production engineers. Once a production manager of a chemical plant said : "To my mind preventive maintenance has no meaning, if I have to stop my plant to carry out preventive maintenance work. As a production man I want my plant or equipment to run always till it breaks down when I should switch over to my stand-by plant and hand over the broken-down plant for repairs". When his attention was drawn to the fact that duplication of entire plant is economically not possible even though smaller equipments like pumps, blowers, sedimenting evaporators etc. may be duplicated, he said. "if one has to have preventive maintenance, plants have to be duplicated and I have seen such plants. Well, I leave it to the readers to draw their own conclusions in the light of their own experience. Preventive maintenance is a vast subject in it self and it is not the purpose of this article to go into details. However, we have to update our knowledge on preventive maintenance and spread the same from the top-most executive to the lower-most maintenance worker.

This could only be done through the help of competent professional plant maintenance engineers.

Plant Engineering Training

Here again, we have to re-orient and revamp the training in plant engineering for the benefit of practising plant engineers, supervisors, maintenance mechanics and technicians. There are no systematic training facilities available in India to spread the knowledge on the principle of operation, construction, and trouble shooting of the multifarious plant equipments and control equipments used in process plants. The training will have to be both theoretical and practical-oriented with good deal of knowledge on metallurgy, corrosion, materials of construction, effects of high pressure and temperature in vessels, pipelines and equipments, effects of low temperature and the materials used to combat such temperatures etc. No doubt a few of our large-sized public sector industries have started their own apprenticeship and other training schemes which are only drops in the ocean and it is suggested that training may be taken up at national scale, leading to award of certificates for pump mechanics, refrigerator mechanics, process instrument mechanics, compressor mechanics, pressure vessel and heat exchanger mechanics, pipeline fabricators, non-pressure vessel and equipment fabricators, electrical and electronic mechanics, chemical plant operators etc.

We have no faculty in our universities for the teaching of plant engineering, although we have production engineering subjects. It is time, our universities think in this direction; and the course that leads to a degree in plant engineering should include special subjects such as plant engineering knowledge, electro-technology, industrial architecture, project engineering and automation in industries.

Plant Engineering Organisation

It should be possible to draw out an organisational chart for plant engineering. But at this juncture, when plant engineering is at the cross-roads no organisation chart will be versatile enough to meet all the foreseeable situations. We can expect that the future demands on plant engineering will be two-fold. If the Ministry of Industrial Development means business, it must see to it that many industries be started with indigenously developed process know-how, using indigenous plants and equipments. In this case the responsibility of plant engineering will be directed towards the construction of pilot plants co-ordinating with the efforts of R & D team and then building up plants on commercial scale. In bigger industrial groups, plant engineering team can function centrally, catering to the needs of individual plants. Even in single plant industries, plant engineering organisation could carry out such jobs like major modifications to plant and equipments to increase production and generally improve over-all efficiency of the plants, besides carrying out systematic maintenance programmes. It can also help develop ad hoc research on day to day operational and maintenance problems by feeding back information to the production and R & D departments on the various maintenance problems which are caused as a result of operational problems, raw materials problems and design inadequacies, wrong materials of construction and inadequate balance in single stream equipments, insufficient storage capacities etc.

Secondly, in setting up of industries where transfer of foreign technology and know-how may be indispensable, the plant engineering organisation should be such that the transfer of foreign know-how could be conveniently done through the plant engineering organisation existing in the industry instead of through individuals who act alone without the backing of a well-organised plant engineering set-up. As already pointed out, this has been one of the main causes of long gestation periods in our industry and eventual failures and capital loss in most of our industries. Let this not be repeated and let us develop plant engineering in all its aspects and utilise it to build our future plants and maintain them for the continued production of goods and services at costs lower than the international standards. ●

Planned Maintenance – An Essential for Production Management

Late Shantilal J. Jain*

Planned Maintenance, in modern industries, with modern machines, where the design emphasis is on reduction of operative labour content has become the life-line of Production Management. The focus is shifting from just running it to a condition of reliably running it without unanticipated interruptions, for a certain known period—hence Maintenance has shifted from the neglected corner of the shop to the front office.

By a case study, various forms of waste occuring in a mechanised or line production engineering plant or process plant, could be traced. An improvement by 10% in the output due to planned maintenance, can increase profit by more than 200%, as demonstrated by an example of a hypothetical company in this article.

INSTEAD of saying that Planned Maintenance is an aid to production in any modern industry, I would put it in a more positive statement that Planned Maintenance is an **essential** to production. This has become necessary in the present-day conditions, when the machines and equipments used by industries, in industrially advanced countries and in India are being designed and installed for increased production and higher productivity.

*Senior Professor and Management Consultant, NITIE, Bombay

Modern Production Machines

If we survey the machines and equipments installed in India after the 2nd World War, we will find that a large part of machinery and equipment has been imported from industrially advanced countries like U.S.A., West Germany, U.S.S.R., France, Japan, U.K., Czechoslovakia, Italy and similar countries. The distinguishing features of these machines are:

— increased unit capacity;
— increased working speeds;
— higher pressures;

— higher temperatures;
— mechanised handling;
— more instrument control (hydraulic, electric, electronic, photo-electric, sound, etc.);
— less involvement of operator;
— higher capital investment.

These developments are natural in industrially advanced economies, where the cost of labour is getting so high that the owners are forcing the designers to incorporate the operative labour part in the machines, by additional capital-intensive designs. And thus there is race for more and more mechanisation and automation so that less and less operative labour is used. It has come to the point that any defect occuring in the process operation, e.g., sticking of a valve in a process industry, is indicated by a light and a buzzer in the control room and the Control Engineer is exactly told where this has occurred and whether an alternative valve has been put in the line and whether it is due to excessive pressure, or temperature or other reasons. Similarly the whole operating processes can be supervised and operated by a computer. In the engineering manufacturing line, a transfer machine can take a rough casting at the first station and turn out a finished component from the casting, after machining it at 10 or more locations, to the required degree of tolerances and finish. The location of the castings at various stations, transfer of the castings from one station to another, approach of the tools for cutting at faster feed, machining at the required speed, return of the tools at faster feed and monitoring of the important dimensions at various stations is being done automatically on the modern transfer machines and numerically-controlled machines. *But what about the maintenance ?* For maintenance we still depend on a person or persons goirig to the machines, opening up the part (rightly or wrongly), trying to find out and troubleshoot what the defect is (even create more defects than what were originally existing) and mentally diagnosing the defect and the cause (just as a medical practitioner diagnoses disease of the patient, with or without the help of various analyses of urine, blood, etc. of the patient). Till now the computer has not taken this over. All this, in the present situation, depends on the training, skill and competence, judgment, initiative and creative ability of the maintenance persons. And what attention have we given to this function as Production Manager ? What sort of diagnostic instruments have we provided him ?

The maintenance job in the present machines requires greater degree of analysis, engineering, knowledge, thinking and ingenuity in addition to the physical task of getting the work done. This is almost a *technical revolution* and this fact is still to be realised by many authorities in Management, Production, Government and Educational fields.

Comparison with Industrially Advanced Countries

Fig. 1 shows a comparison of some of the parameters existing in the industrially advanced countries and those existing in our country. Does this comparison have a significance for us ?

Our Emphasis on Machine or Equipment Utilisation

To my mind, this means that we should utilize these imported modern machines to their utmost, i.e., produce utmost on these machines

Comparison of Some Parameters in Industrially Advanced Countries and in India

Parameters		Industrially advanced countries	India
Capital	Local	Plenty	Shy
	Foreign Exchange	Plenty	Scarce
Technology	Design / Operation / Maintenance	Advanced	Developing
Availability of Labour		Shortage	Plenty
Spare parts availability	Cost	Cheap	Higher
	Time	Very less lead time	Very high lead time
Exchange Ratio	Cost of Machine / Weekly Wages of Labour	$ 10,000 / (40 x $ 4 = $ 160) = 62.5	Rs 1,00,000 / Rs 1600 per week = 62.5

Figure—1

with proper maintenance, so that we reduce the idle time of these machines to the minimum (even zero if possible). This also means that capital being much costlier to us than the man operating or maintaining it, we have to elongate the useful life of these machines and equipments (in industrially advanced countries, perhaps, they would not think this way). This also means that the utilisation of machines has much higher priority to us in India than the utilisation of man (which again may not be applicable, to the same degree, in industrially advanced countries).

Objectives of Company

This, therefore, serves to guide us towards formulating the objectives of the maintenance department, which is one of the departments helping production and sales departments to achieve the objective of the company—

> to supply a needing customer with specified quality goods or services at the required time, in required quantity and at a willing price so as to generate a *surplus or profit* for distribution to shareholders, employees, suppliers, Government and community.

Objectives of Maintenance Department

This, in turn, leads us to the objectives of the Maintenance Department which can be enumerated as:

1. helping manufacture in larger quantities;
2. helping manufacture for higher market values;
3. helping manufacture at lower cost;
4. helping in timely manufacture;
5. higher safety and longer life for equipments;
6. higher safety and morale for employees;
7. better environment for community.

Idea of Downtime Costs

I would now like to consider the magnitude or order of the downtime costs. For a company, this modern equipment has meant much higher investment—both in terms of rupees and foreign exchange, greater amount of vulnerability if the equipment is down, much greater amount of inter-dependence of equipment and processes. This also leads to a huge amount of sales turnover loss or downtime loss and consequently quicker loss of PROFITS. If the production machines encounter breakdowns at unplanned time, a very rough estimate of sales turnover loss, is as follows :

Paper Machine	100 tonnes per day.	Rs. 8,350/- per hour.
Cement Mill	600 tonnees per day.	Rs. 5,500/- per hour.
Truck Manufacture	30,000 trucks per year.	Rs. 3,10,000/- per hour.

* A passenger bus off road one day loses about Rs. 1,000/- to Rs. 1,500/- per day.
* A petro-chemical complex loses *profit* of Rs. 3 lakhs per day of interruption (unplanned).
* It takes anywhere from 4 hours to 5 days to stabilise working of High Pressure Ammonia Plant in a Fertilizer Complex.

A Case Study

May I now cite a case study which may ring a familiar tone to many readers.

A reduction gear box, connected to a sand-muller in a foundry, doing mechanised production, did not have its bearings replaced on a planned schedule. The sand-muller was working to keep up the target of the production manager. The bearings failed while a 'lot' of important castings was 'on'. Due to the failure of the bearings, the worm shaft was bent and the worm cracked. The analysis was done as under:

In this case, the factors which were unplanned for and increased the costs were the spare parts and the equipment availability for planned maintenance.

Many such examples can be cited from practice, but these costs are not brought out by existing costing procedures, unless presented in a manner depicted above. With these types of increased cost or waste occurring in our industries, it is no wonder that our productivity is one of the lowest in the industrial world and the burden of this is to be borne by the ultimate consumer in terms of higher costs and higher prices and consequently, the present inflation in our country.

Increase in Profitability

If we take a look at the existing profit and loss statement of an average hypothetical Indian Company, it presents a picture as shown in the bar chart in the diagram, with the types of wastes occuring, as shown in the case study. I am venturing to suggest that we can increase by 10 per cent, the volume of existing production i. e., produce and sell additional 1,000 units at Rs. 100/- per unit. In this case I have taken that we are incurring marginal costs of Rs. 10,000/ for material, Rs. 2,000/- for labour and Rs. 3,000/- for factory expenses, assuming that we have now a Planned Maintenance System in operation. This means that we have generated a surplus of Rs. 85,000/- from those additional sales of Rs. 1,00,000/-. Thus this shows that due to 10 per cent increase in productivity due to Planned Maintenance, the increase in profit is

$$\frac{60{,}000+85{,}000}{60{,}000} \times 100 = \frac{145}{60} \times 100 = 241\%$$

This figure, I may assure the readers, is not out of our reach. This gain due to increased productivity has to be shared between the shareholders, employees, suppliers, Government and community, in accordance with companies' objectives, if the Company plans for its continued survival in the existing social and economic atmosphere, in our country.

This brings me to the chart showing the relationship between various forms of maintenance as enunciated by British Specification 3811 : 1964.

From an article published in Factory Magazine in 1958 the following *'soft spots'* (vital function areas) were discovered in Industrial Maintenance and corrective action taken to create a Planned Maintenance Programme. It is now paying off as follows[1] :

"Fewer machine failures .... Better management control of maintenance manpower .... Performance of machine repairs within budgeted standards. .... Smarter decisions among supervisors, who now have more information than before...An increase of 50% in the number of major overhauls handled right in the department (instead of being contracted to outsiders) .... A sharp drop-off in complaints from departments serviced by the maintenance department.... Smooth operations, resulting from positive direction and controls instead of a series of crises..... A downturn in cost of running the Maintenance Department."

1. Loose Supervision

Problem — Supervision was spread too thin for effective control in a plant covering 28 acres, etc.

Solution — Improving the telephone system and providing a clerk to do routine detailed work.

2. Slow Services

Problem — Time lost due to bad methods of distributing pay cheques and varied timing of lunch hours for various trades.

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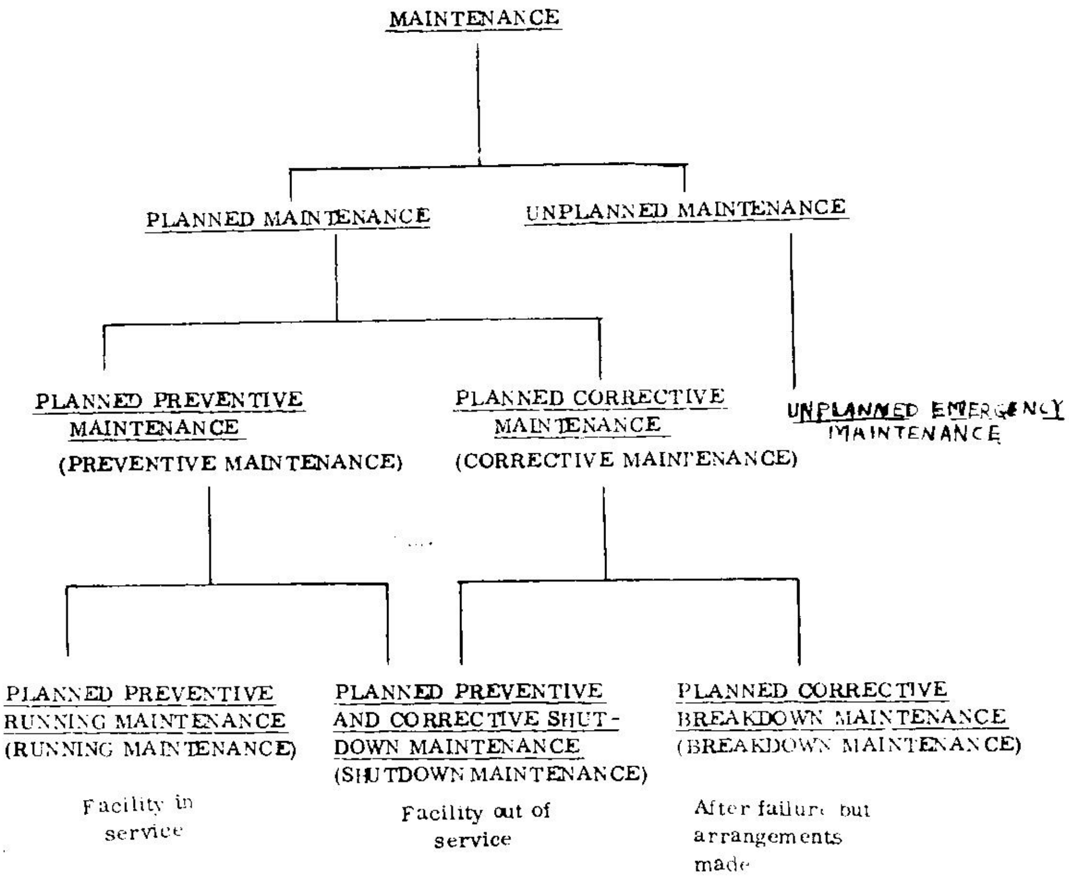
[1] Suffixes indicate references given at the end.

Chart Showing the Relationship Between Various Forms of Maintenance



Figure—2

Solution — Cheque cashing service re-located. Machine repairmen, fitters and electricians assigned the same lunch hours.

3. Poor Assignments

Problem — Machine repair fitters normally work without blue-prints, etc.

Solution — Written instructions, information on location of material and a sketch is provided for each job. Also time is estimated.

4. Oiling Failures

Problem — These like Nos. 5, 6, 7, and 9 fell into the pattern of repetitive repair that were costly enough to justify specific controls to reduce their frequency.

Solution — Lube point modified to ease servicing. Sight gauges are cleaned and kept in good order. The 2 machine inspectors represented an added cost for about 12 months before we realised enough benefits to return to the original personnel allowance. We expect further cost reduction as the longer range phases of the programme begin to show results.

In several dramatic cases our improved procedures have averted machine damage due to lube failure. Continuity of lube services is obtained in spite of personnel changes.

5. Faulty Procedures

Problem — Scored ways of machine tools caused by inoperative way-wipers.

Solution — Way-wipers are checked in each inspection. Those that are inoperative are repaired at once.

6. "Quickie" Repairs

Problem — Regardless of kind, these five-minute jobs often took 30 minutes by the time we added make-ready, travel and put-away time.

Solution — Now, if "quickie" repairs can be done in less than 30 minutes, they are done by the inspectors as found and are charged to the patrol order.

7. Air Tool Repairs

Problem — Air-powered nutrunners and grinders used to fail prematurely, mostly because of moisture and scale in airlines. Keeping these in service in summer was a two-man job.

Solution — Using filters and oilers of more recent design. Started replacement programme after we found that a new filter and oiler set not only cost less than one major repair, but also quadrupled the time between the major changes.

8. Uncontrolled Labour

Problem — We needed a sound basis for better management and control of manpower.

Solution — Budget controls were based on plant-wide productive manpower. These controls have been refined with a manning chart. This chart relates personnel needed for performing running repairs to productive manpower.

9. Hydraulic Failures

Problem — These took disproportionate repair time because of damage arising from faulty operation (due to control failure) or because of control itself.

Solution — Inspectors daily select one machine that needs attention. They arrange with the responsible foreman to have its hydraulic system cleaned and oil replaced.

"Written procedures on airline filters and oilers and hydraulic systems are now incorporated in the plant's supervisory policy manual".

10. Random Overhauls

Problem and Solution — Overhauls must now be okayed by management after proper investigation. Estimated hours are added to a backlog. Personnel maintained for overhauls are not used on running repairs.

11. Unpredictable Work

Problem — This includes, for example, experimental samples, special orders and revamping equipment for new jobs. These jobs are handled as backlog rather than running repairs.

Solution — Management now has a good measure of the work ahead of the department of the manpower required to perform that work. All scheduled work that is added is evaluated by management before it is done.

12. Costly Patchwork

Problem — Overhauls usually are based on need for production. But we found some equipment being patched at greater long-term cost than effective overhaul.

Solution — The budget department now picks up such cases from machine cards or from machine repair supervision and initiates overhaul requests. A temporary group of three men is performing these repairs.

13. Loose Inventory

Problem — We had never made formal provision for storing and recording units removed from machines (tables, knees, spindles, attachments, etc). We had sold machines as surplus, without including such equipment, thus incurring a loss on the sale price, increasing disposal cost and cluttering up certain shop areas. Also, there was nothing to keep us from buying a unit already on hand.

Solution — We have developed procedure for a salvage crib. But it must wait until space becomes available after a company division moves to a building now under construction.

14. Disorderly Buying

Problem — Although we did not keep parts cost data, the maintenance general foreman was responsible for ordering spare parts, determining which parts to stock, whether to make order or buy any parts. Also requests for appropriations to cover major repairs were based on his estimates.

Solution — Making the Maintenance General Foreman the requisitioner of machine parts overcame this obstacle. His clerk now maintains a card record of parts purchased and a file of price quotations. The clerk receives a copy of all orders placed. Now, estimates to make and decision to buy are more accurate. Follow-up takes less time and parts are no longer 'lost in the plant'.

15. Unrecorded Costs

Problem — We found that parts cost was not reaching the machine history card. We also found that between 120 and 140 labour charges per month were being incorrectly made.

Solution — So we set up new procedures that have almost eliminated these conditions. We do not pursue minor errors, but the correct machine number must be determined if an expenditure of more than $ 10 is involved.

16. Weak Control

Problem — Production foremen sometimes felt they could not release a machine that needed repair but could still be operated. After an instance of severe damage due to this practice, we reserved such decisions for the plant manager or his assistant.

Solution — An independent investigation revealed that the practice of moving machines to the central shop for repair could be overdone. Sometimes moving expenses even exceeded repair costs. Now no machine can be moved without approval of the assistant plant manager.

"None of these latter problems are directly a part of the control procedure. But each represents a real or potential source of excess cost or waste and indicates how important it is for each supervisor to have his own situation under control".

Approaches to the Problem[2]

When word comes down from the front office that maintenance costs are too high and must be reduced and that the operating time for equipment is not satisfactory, there are two ways of handling the situation. One is to take a good hard look at maintenance management methods (which we are doing in the latter part of this article) and improve them; the other is to use the "snow job" technique. The latter technique is not one to be passed over lightly since it is often used, not only by lower-level supervisors but also by department heads. The basic idea is simple and relies on the principle that "you can fudge anything but the total".

With this in mind, you never deal with anything but programme increments. The following is a list of approved phrases, which are followed by a more exact English translation:

1. "The percentage of jobs completed on schedule has increased". (WE CHANGED FROM WEEKLY TO DAILY SCHEDULING AND WILL GO TO HOURLY IF YOU BUY THIS).
2. "Our backlog of work is greatly reduced". (WE TORE UP SOME REPAIR ORDERS).
3. "Overtime is much less." (THERE ARE TOO MANY MEN ON THE PAY-ROLL).
4. "Equipment is in better condition since fewer repair orders are being received". (WE STOPPED INSPECTIONS AND NOW HAVE ONE BIG REPAIR JOB INSTEAD OF SOME SMALL MAINTENANCE WORK).
5. "There are less men in the maintenance department". (WE STOPPED MAINTAINING THE PLANT AND ARE HOPING LIKE MAD FOR A TRANSFER BEFORE THE SITUATION CATCHES UP WITH US).
6. "Emergencies do not interfere with scheduled work". (WE DON'T SCHEDULE, AND WE HAVE TOO MANY MEN ANYWAY).

May I, therefore, suggest that the effective Planned Maintenance Management Programmes follow 25 simple rules (with some rules added to ones suggested by Lewis & Pearson[3]).

1. Attitude change in company and production management.
2. Establish a responsible organisation.
3. Make an inventory of equipment and keep equipment history sheets and records.
4. Categorise the equipment.
5. Use a work order system and do work order analysis.
6. Analyse and plan every job.
7. Do work study on maintenance jobs—method study, work sampling and work measurement.
8. Forecast two-yearly, quarterly, and monthly requirements.
9. Set up a Planned Maintenance Programme.
10. Use diagnostic instruments and formulate performance in i:es where possible.
11. Set up a manpower control.
12. Prepare weekly schedules.
13. Use budgetary control.
14. Provide material control.
15. Plan shutdowns.
16. Do design modification, classification and development of indigenous spare parts—use inventory control.
17. Establish measurement and quality control of spare parts and supplies.
18. Work for a simpler government procedure for import of minimum required spare parts.
19. Establish major overhaul procedures.
20. Develop standard inspection practices and inspection intervals.
21. Improve equipment for operation and maintenance.
22. Train supervisors of management, operation and maintenance.
23. Train men in operation, maintenance and other functions.

24. Analyse performance and cost.
25. Think of maintenance prevention and standardisation at the procurement and design stage.

All these rules conform to the management cycle which applies to maintenance, which is a sub-business operated within the main manufacturing business, e.g.,

1. establishing objectives,
2. planning and organising,
3. taking action, motivation and co-ordination,
4. measuring, controlling and evaluating results.

Bernard T. Lewis in Maintenance Management[3] describes the relationship of "Management Cycle" to the fields of activity and inherent functions of control in maintenance as shown in Fig. 4.

Incorporation of these steps has transformed haphazard maintenance into "Systematic Planned Maintenance"—*an essential and positive tool for stabilising and increasing production and productivity*—the objective of Production and General Management.

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2. Miller, Elmo J Blood, Jerome W — Modern Maintenance Management, American Management Association, New York-1963.
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Conformity : The Path to Job Advancement

Conformity, compliance with company objectives and servility are the qualities that most help executives to climb the promotional ladder. This is the finding of a survey of 200 middle managers at 40 firms in southern Germany. It shatters the long-held belief that inborn or acquired leadership qualities are most likely to lead to success. The study was carried out by the sociological research centre at Friederich Alexander University in Erlangen. Its aim was to find out the criteria for a successful management career. The study found that the executives most often promoted were those who showed a "positive attitude towards their superiors, the work situation and the enterprise itself." In other words, success came most readily to those who complied with established company practices rather than those who tried to impose their own personalities on an organization.

Evaluation of the Effectiveness of Maintenance

K. Ramesam*

An effective maintenance system must maximise the availability of machinery and equipment for unhindered production, preserve the value of plant, machinery and equipment by minimising wear and tear, ensure the industrial safety, and accomplish these three objectives as economically as possible on a long-term baiss. As such, the maintenance performance must be measured vis-a-vis the above-stated objectives. It must be admitted that no single variable can be made a yardstick to evaluate maintenance performance; instead, it has to take into account a variety of complex factors and further they have to be adapted to the operating situations in different plants to produce meaningful results. In general, however, the essential elements of any evaluation programme should cover organisation, policy and procedures, cost control, breakdown and preventive maintenance, work measurement and workload control, inventory control, maintenance budget, training for maintenance and finally reporting to management.

EVALUATION of maintenance performance is admittedly a difficult task. It is impossible to select a single criterion, which gives a meaningful measure of performance in the wide array of industrial plants that we come across. It is also impossible to select any single measure with which to gauge maintenance performance in any one industry or even plant. Fair evaluation demands the use of many factors. There are a multitude of yardsticks which can be used. These yardsticks have to be adapted to the operations in different plants to produce meaningful results.

The overall objective of every maintenance operation is to make the greatest possible contribution to the long-term profitability of the Company or Plant. Objective evaluation of maintenance performance in terms of a broad goal, appears most feasible by breaking down the overall objective into four sub-goals.

1. Maximise the availability of machinery and equipment for production;
2. Preserve the value of plant, machinery and equipment by minimising wear and deterioration.
3. Accomplish these two objectives as economically as possible on a long-term basis.
4. Ensure the safety of all the employees of the Company.

Our technique of evaluating performance against these goals involves analysis on a step-by-step basis.

The first step consists of gathering information on the actual physical condition of the plant in order to assess its capability to produce, both from the qualitative and quantitative

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angles. The investigation would also throw light on the degree of depreciation incurred by the plant.

Secondly, a thorough study is made periodically to assess how the Works Engineer has set up the organisation of the Maintenance Section to provide effective, efficient service to attend to breakdowns or preventive maintenance.

The final step is the analysis of historical data on machinery and equipment downtime, the trend of expenditure on plant maintenance, the level of maintenance inventory, the employment of maintenance personnel in relation to the total establishment of the plant, the effect of maintenance on critical machines, the break-up of various causes of breakdowns etc. Our experience in evaluating maintenance performance in a number of situations indicated that whenever a specific study of any trend is seriously undertaken, a sound maintenance and cost control programme always showned the greatest reduction in machinery downtime and the most favourable trends in the cost of maintenance.

The essential elements of any evaluation programme should cover the following aspects:

1. Organisation
2. Policy and Procedure
3. Cost Control
4. Breakdown and Preventive Maintenance
5. Work Measurement and Workload Control
6. Inventory Control
7. Maintenance Budget
8. Training for Maintenance
9. Reporting to Management.

Thus the above individual items and organisation techniques, which contribute to superior maintenance performance, become yardsticks for evaluating performance.

Organisation

Since effective maintenance performance depends upon planning, internal communication and the co-ordinated efforts of many individuals, proper organisation of the maintenance group is fundamental to sound operations. While good organisation is never a rigid system, we believe that every maintenance activity must have a written organisation chart, which clearly shows how the work-load is logically divided and at the same time, how the divided parts are properly coordinated.

We have found that for best operation of the maintenance activity, the person having overall responsibility for the maintenance function—the Works Engineer in the case of Lucas-TVS—must report to the person having the overall responsibility for the entire plant and not to the person in charge of production. In the case of the latter type of organisations, there is the danger that maintenance problems will be subordinated to production problems, with detriment to the ultimate well-being of the plant. This then becomes a point to examine in any plant.

Another criterion for maintenance organisation, which has an important effect on maintenance efficiency, is the Supervisory Ratio or the number of craftsmen supervised by one Foreman. In general, an optimum ratio of 15 to 18 is considered advisable. There is no doubt that this ratio varies from Plant to Plant, depending on the job assignment, the work supervised and the area over which the operations are spread out. The Supervisory-Craftsmen ratio then becomes another yardstick to use.

Good organisation does not mean that good performance of maintenance is being achieved ; however, good organisation undoubtedly sets the stage for increased likelihood of superior maintenance performance. Therefore, it is considered that organisation of the activity constitutes a significant clue in evaluating performance.

Policy and Procedure

In order to hold the maintenance group at a high level of performance, it is essential that a well-thought-out policy and procedure is laid down to be followed. It should be ensured that this policy and procedure is clearly understood by all the personnel of the maintenance group that are charged with the responsibility of implementing the policy and Procedure.

For instance in Lucas-TVS, there is a Machine Tool Examination Section, separately constituted, to report to the Works Engineer the results of evaluation of maintenance from time to time. There are a number of printed standard forms devised to cover the following aspects of plant condition.

1. Report on new or reconditioned machine tool examination;
2. Plant examination report;
3. Machine Tool Examination Report;
4. Machine Tool Spares Schedule;
5. Plant Data Sheet.

Standard forms are also at present in use for recording Preventive Maintenance Inspection, for Lubrication Periodicities and Performance of Lubrication Programmes on a machinewise basis. It should be borne in mind that evaluation of plant maintenance starts when it is contemplated to purchase a plant and continues through various stages upto the time it is decided to condemn and replace the plant. The production plant purchase is generally the function of the production Engineering Department, who carry on the initial negotiations with the Plant Suppliers in conjunction with the Buying Department. When purchase of a certain plant is contemplated, it is usual practice in Lucas-TVS to hold meetings amongst representatives of process Planning, Plant Layout, Purchase and Works Engineering personnel to assess the various aspects of the plant in question. The Works Engineering Department should invariably be invited to advise on the maintenance and repair aspects of the plant as also the forecast requirement of spares.

Next in importance to the 'Purchase' comes the 'Layout' of the machine. Well before the machine arrives in the works, a Layout Note is released, indicating the exact position of the machine or group of machines, the services required for the machine and the purpose for which the machine is being installed. At this stage, the maintenance group has an opportunity to evaluate the layout, particularly in respect of cost of services, accessibility to maintenance, safety of the operator, any other special services such as fire-fighting facilities and so on. Generally such requirements are incorporated in the Layout Note, which is released for implementation after obtaining due concurrence of the Works Engineer.

Thus, it is essential that a well-defined policy and procedure is established for ensuring effectiveness of maintenance.

Cost Control

In order to control maintenance cost, it is necessary that the Works Engineer be constantly advised of the details of his expenditure. The value of proper cost information has not been universally accepted or appreciated by all maintenance organisations with the result that a paradox is created that while the average sophistication level of cost programmes in many of today's plants has been determined by the presence of automatic data processing and effective feed back, cost programmes in plant maintenance and engineering have tended to be primitive or at best traditional. It is indeed rare to find plants using feed-backs supplied by Accounting to discover the need for modification of its procedures. Exceptions, no doubt, exist in some process industries, where safety or economic considerations have forced such a disciplined approach.

In some plants, including the Company for which the author works, it is not considered that maintenance labour should be separately costed on a jobwise basis with the result that labour cost has necessarily to be evaluated as a general overhead. It is a matter for consideration whether maintenance labour cost should be identified separately and related to individual jobs. This approach may be particularly useful in evaluating work measurement and work-load control.

Apart from the departmental labour cost, the Works Engineer has means of booking material costs on a Job Number and cost of contract labour and material on a Sanction Number. In order to facilitate individual expenditure, an analysis number is assigned to every job in the works. It is thus possible to make a comparison between actual expenses incurred during two specific periods and thus establish trends of maintenance expenditure. By making this report available on a weekly basis, the Works Engineer can be enabled to take prompt action in analysing and correcting any undesirable trends.

As explained earlier in this paper, the maintenance function can achieve important savinge by actively participating in the determination of design requirements and specifications for proposed new machinery and equipment. The works Engineer can ensure that production machinery and equipment being procured, are designed and constructed to operate with a minimum of production downtime and so that all maintenance can be performed efficiently.

The Works Engineer has unique qualifications to review and analyse machinery and equipment designs while they are still in the blueprint stage and before the order is placed with a manufacturer. This is the time to request changes in the Supplier's designs so as to 'build in' such features as :

1. Ease of repairs;
2. Ease of access;
3. Ease of component replacement;
4. Interchangeability of parts or components:
5. Trouble-shooting aids built into the control system.

Experience gained in the maintenance of units similar to those being purchased, must be applied to assure that the new machinery and equipment can be maintained effectively at low cost.

Accurate and complete reporting and recording of the downtime of production machines are essential to the evaluation of maintenance performance. Any plant which is not now recording machine downtime should start this type of programme as an essential element in evaluating performance. Machine downtime expresssd as a percentage of scheduled machine production time is a direct and objective answer to the question 'To what degree is the Maintenance Department succeeding in its goal of maximising the availability of machinery and equipment for production?". Historical trends shown graphically on a machine downtime chart are of great value in relating past performance to the present position and even more important for setting up realistic goals for future improvement. Downtime records on an individual machine alert Management to design weakness and should guide future purchases. Analysis of the causes of downtime on a particular machine provides excellent guidance in correcting design problems. Eliminating the need for repetitive repairs is a most effective way to reduce both manufacturing and maintenance costs.

Valid comparisons can be made of downtime percentages between plants having similar production processess, provided that both plants define 'machine' in the same way. At our Company, the definition covers all lost production hours resulting from maintenance deficiencies as 'the malfunctioning or breakdown of a machine (or equipment) during a production period without consideration of whether a stand-by unit is available or whether a float of parts exists.' The scheduled withdrawal of a machine from production for planned maintenance is not classified as downtime because of machine failure.

Breakdown and Preventive Maintenance

Analysis of downtime owing to breakdowns and the attributable causes was conducted in our plant in order to assess the quantum of Preventive Maintenance to be introduced. The analysis revealed the following major causes in order of their frequency.

1.	Natural wear & tear	30%
2.	Improper and possible negligent/ignorant operation	.. 20%
3.	Inadequate maintenance (sometimes owing to non-availability of machine tool and sometimes owing to non-availability of spare and consequent improvisation)	.. 15%
4.	Lack of lubrication and cleaning	.. 15%
5.	Poor design and construction	.. 10%
6.	Other miscellaneous causes such as wrong location, bad layout, and operation without the right accessories	.. 10%
		100%

Though the downtime figures generally illustrate the incidence of breakdowns, they do not pinpoint idle time on machine tools or plant, which are one of its kind and any downtime on them is likely to create a bottleneck in production because of lack of stand-by machines. Therefore a study was carried out on all such critical machines numbering about 75 in our plant and constituting about 8% of the total available plant. Preventive Maintenance was introduced on these machines with good results.

The following figures indicate the trend of downtime in our plant from 1966-1969.

I. Scheduled Availability of Machine Hours

1966	—	10,32,300
1967	—	12,00,000
1968	—	14,08,000
1969	—	15,12,200

II. Downtime due to Breakdown in Machine Hours.

1966	—	9680
1967	—	8750
1968	—	9790
1969	—	11130

III. Downtime expressed as a percentage of Scheduled Availability of Machine Hours.

1966	—	0.93
1967	—	0,73
1968	—	0.70
1959	—	0.73

The above results appear very effective, but due note must be made of the fact that the plant in the factory is still comparatively new and most of the additional machine hours in the scheduled availability in the later years are due to new plant being added. Nevertheless the figures illustrate how an effective factor of evaluation can be provided by the study of downtime.

It will be useful to have a questionnaire as detailed below for seeking an evaluation of maintenance performance:

1. Are machines, equipment and the plant covered by scheduled inspections ?
2. Have inspection routes been established to obtain maximum efficiency ?
3. Have written inspection check-sheets to guide the work of the inspector been made out for all machines and equipment covered by the inspection programme ?
4. Have optimum inspection frequencies been determined ? Are they revised to reflect most recent experience and operating conditions ?
5. Are actual inspections made on schedule ? Has an efficient follow-up system been set up to detect failure to complete inspections on schedule ?
6. Are written requests for maintenance service issued for all deficiencies discovered (except for adjustments and minor repairs performed by inspecting craftsmen) ?
7. Is all lubrication performed on a scheduled basis using written lubrication check sheets ? Are these check sheets revised so that they reflect the latest plant changes ?
8. Has adequate consideration been given to the design of forms used in the programme and to the flow of copies to ensure minimum clerical costs ? Are Data Processing techniques used wherever equipment is available ?
9. Are historical records kept of significant repairs ? Are these records reviewed periodically to determine where improvements can be made in the inspection, repair, operation or design of machinery and equipment ?
10. Is the ratio of downtime to scheduled idle time under control ? Does it show a trend towards reduction ?

It is believed that each negative answer to the above questions indicates a potential area for improvement in maintenance performance.

Work Measurement and Work-load Control

Work-load control can be defined as 'The determination of how completely the Maintenance Department can determine its work-load, balance manpower with work-load, forecast desirable changes in the size or make-up of its work-force and influence priorities for effective use of Department's resources.

One of the most useful techniques for evaluating labour performance is work-sampling. This is a method of observation to obtain more information about an activity than it is practical to get by continuous observation. The underlying theory of work sampling is that random observations reflect accurately the average percentage of his total time actually spent in non-productive activities such as walking to the Tool Crib or Maintenance Stores. Loss of efficiency results mainly from delays and time spent in transit. Work-sampling indicates just where the time is being spent. If too much time is being spent in travelling to and from the job, in hunting for tools and equipment, requisitioning material or parts or getting more information about the job, steps can be taken to make improvements.

Unfortunately in the plant of the author, since maintenance labour is deemed as an overhead on an overall basis, much work has not been done in this direction. However, a marginal degree of control is maintained in relating maintenance employment to the total plant force. The following table gives at a glance the increase in the Works Engineering strength (Maintenance and a small component of construction establishment) in relation to the increase in overall strength and the production strength.

	W.E.D.	Production	Total Factory
1966	115	688	1214
1967	129	672	1238
1968	140	821	1457
1969	151	1004	1740
1970	165	1061	1913

It is said by some authorities that this strength for a light engineering factory should not exceed 10% of the total plant force. It can be seen that going by this figure, the strength of Works Engineering is well below the permissible maximum. Admittedly this is not a refined index for evaluating the labour performance and to be successful, a work measurement programme designed to improve maintenance should be implemented by taking into account the following factors :

1. Establish the approximate time required for each task so that effective planning and scheduling can be accomplished.
2. Replace the Supervisor's job estimates taken at 'random from his hat' by better-founded Job-Time Data.
3. Provide an accurate basis for staffing maintenance crews.
4. Provide a means for measuring the effectiveness of maintenance force, both supervisory and non-supervisory.
5. Furnish yardsticks to measure departmental, area or group performance.

Inventory Control

Much has been said on this subject in the author's paper entitled 'Control of Maintenance Stores and Spares'. An evaluation of the residual inventory value in the Stores in comparison to the age of the plant and the turnover of the Company, could prove a useful yardstick. Given below is the trend of inventory in our factory as compared to turnover.

	TURNOVER	INVENTORY
	Rs.	Rs.
1965-66	422,12,000	3,50,000
1966-67	441,84,000	3,96,483
1967-68	513,79,000	6,00,000
1968-69	637,51,000	8.00,000
1969-70	684,03,000	10,00,000

From the figures it can be seen that the inventory has gone up considerably and suitable steps have to be taken to reduce it by reviewing the movement of spares.

Maintenance Budgeting

Annually, the Works Engineer, in conjunction with the Factory Administration, prepares a Maintenance Budget. This budget is a financial document which represents Management's best reasonable estimate of performance for the ensuing year and is essentially the formulation of Maintenance Plans expressed in Rupees.

The use of budget performance is such a simple and apparently straight forward technique of measuring maintenance performance that we have found cases in the past in which its significance has been overstressed. We take the position that good or bad budget performance may be achieved while excessive deterioration of plant and machinery is allowed to occur. Likewise, budget performance in the Maintenance Accounts gives no indication of production machinery availability nor of machine downtime due to maintenance deficiency.

In our plant, Maintenance Budget Performance is evaluated on a monthly basis by comparing the actual maintenance expenses to budgeted or authorised expenses. Once we realise the limitations of budget performance as an indicator in evaluating maintenance performance we have a useful tool not only for comparing week to week operations but also for comparing trends for a period of 5 or 10 years.

Plant Maintenance Budgets are prepared on the following heads :

A. POWER & LIGHTING

1. **Electricity Charges.**

B. MAINTENANCE MATERIALS

1. Furnace Oil & High-Speed Diesel.
2. Machinery & Equipment Spares :
   (a) Spares for Breakdown Maintenance & Preventiue Maintenance Repairs:
      (i) Imported
      (ii) Indigenous
   (b) Spares for Reconditioning :
      (i) Imported
      (ii) Indigenous
3. Chemicals for water & effluent treatment.
4. Cleaning materials for factory sanitation.
5. Building materials & Estate maintenance.
6. Lubricating Oils, Greases & Solvents.
7. Steel Pipes, G.I. Pipes, Pipe Fittings, other hardware, batteries, miscellaneous materials required for service (excluding machinery spares).
8. Training, Travel Expenses, Stationary including Drawing Office materials, Trunk Call Charges, Books and Periodicals.

C. CONTRACT MAINTENANCE

1. Annual Contracts of Special Equipments.
2. Sub-Contract Maintenance and Service Charges for Plant & Equipment.
3. Maintenance of Telephones.
4. Replacement of lamps, chokes and general cleaning of lamps in factory area.
5. Replacement of lamps and repainting of reflectors in office area.
6. Maintenance of Sub-Station and Earth Pits.

7. Earth Work, Bunding etc.
8. Wearing Coat for Roads.
9. Works contract for painting, sewage, drainage maintenance, white and colour washing offices and factory.
10. Repair of Office Furniture.
11. Horticultural Treatment.
12. Minor and miscellaneous work not included in the above.

D. REPLACEMENT

1. Tanks in Plating Shop.
2. Barrels for Plating Plant.
3. Window Airconditioners for rooms.

E. STAFF AS REQUIRED

One can readily appreciate the significant advantage of such a detailed breakdown of maintenance expenses, We are able to know the specific area of maintenance expense variance and take reasonable steps to correct it or at the very least be guided towards a factual explanation of the variance. Budget Performance Reports alone do not reduce variances; it is the efforts of individuals, who are stimulated by these reports that improve maintenance performance. The value of using Maintenance Budget as a means of evaluating maintenance performance hinges largely upon how good a budget the Works Plant Engineer has built up.

Training for Maintenance

In evaluating training programmes for maintenance personnel, we seek answers to the following questions :

1. Has provision been made for selecting qualified men for determining standards of performance of trainees ?
2. Has provision been made to measure performance of trainees against a given standard of performance ?
3. Has the programme content and level of instruction been designed to meet the specific training needs of the plant ?
4. Has the responsibility for the training programme been delegated to a qualified individual so that the details of the training programmes are effectively administered ?

Analysis of answers to these questions guide us in evaluating the degree of success of the training programme in contributing to improved maintenance performance.

Management Reporting and Maintenance Control Indices

Since Maintenance Productivity is the aim of Maintenance Management and Control Indices are necessary to assist Management, an index of Maintenance Productivity would provide an essential overall guide.

Maintenance Productivity Index can be defined as the ratio of 'The Output of Product' to 'The Cost of Maintenance Effort'. If this index is accepted as a valid indicator of productivity then it can be used to determine the factors affecting productivity which are within the control of the Maintenance Engineer. Indices can then be devised for these factors which can be used by Supervisors and Maintenance Managers to guide their efforts in the right direction. Defining Maintenance Productivity Index in a mathematical way :

$$\text{M.P.I} = \frac{\text{Output of Product}}{\text{Cost of Maintenance Effort}}$$

Factors affecting the numerator (Output of Product), which are within the responsibility of the Maintenance Engineer are :

(i) Duration of scheduled shutdowns.

(ii) Duration of breakdowns.

(iii) Duration of use of defective plant on reduced throughput.

(iv) Manufacture of waste product due to defective plant.

Factors affecting the denominator (Cost of Maintenance Effort), which are within the responsibility of the Maintenance Engineer are :

(v) Overtime hours worked.

(vi) Labour performance of Section.

(vii) Methods of repair.

(viii) Inspection devices in use.

(ix) Frequency of lubrication inspections and repairs.

(x) Standardisation of parts and equipment

(xi) Design of equipment.

(xii) Use of uneconomic materials for equipment.

(xiii) Excess stocks of spare parts.

It has been stated that the Maintenance Engineer's function is to :

(a) Decide the economic volume of work.

(b) Undertake maintenance requirements at the right time.

(c) Reduce the labour and material cost of all jobs to the lowest possible level consistent with safety and quality.

It will be evident that these three requirements which are aimed at increasing productivity, are also affected by the 13 separate factors enumerated above.

It is not proposed to go into the evaluation of all these 13 factors. But one or two examples can be illustrated.

Overtime Hours

Overtime hours carry invariably a higher labour cost and should, under most circumstances, be kept to a minimum. A simple index for control would be :

$$\frac{\text{Overtime Hours}}{\text{Total Maintenance Hours}}$$

(Or)

$$\frac{\text{Overtime Wages}}{\text{Total Maintenance Wages}}$$

Excess Stocks of Spare Parts

If the capital tied up in inventory of maintenance spares is relatively significant, it may be studied by the following index :

$$\frac{\text{Cost of Maintenance Materials used}}{\text{Total Cost of Maintenance Stores on Hand}}$$

Use of Control Indices

It will be preferable to evaluate the above guidelines and convert them into trend graphs as the latter would damp out any fluctuations. The Moving Annual Total (M.A.T) or Moving Annual Average (M.A.A.) are normally satisfactory, but more sensitive graphs with quarterly and monthly periods may be introduced when required.

Reporting to Management

It is customary in Lucas-TVS to make a report to the Management on the trend of maintenance, highlighting plant incurring excessive downtime, design imperfections, premature failures, plant replacements and other relevant statistics at monthly, quarterly, half-yearly and annual periodicities. ●

SCHEDULED AVAILABLITY OF M/C HOURS

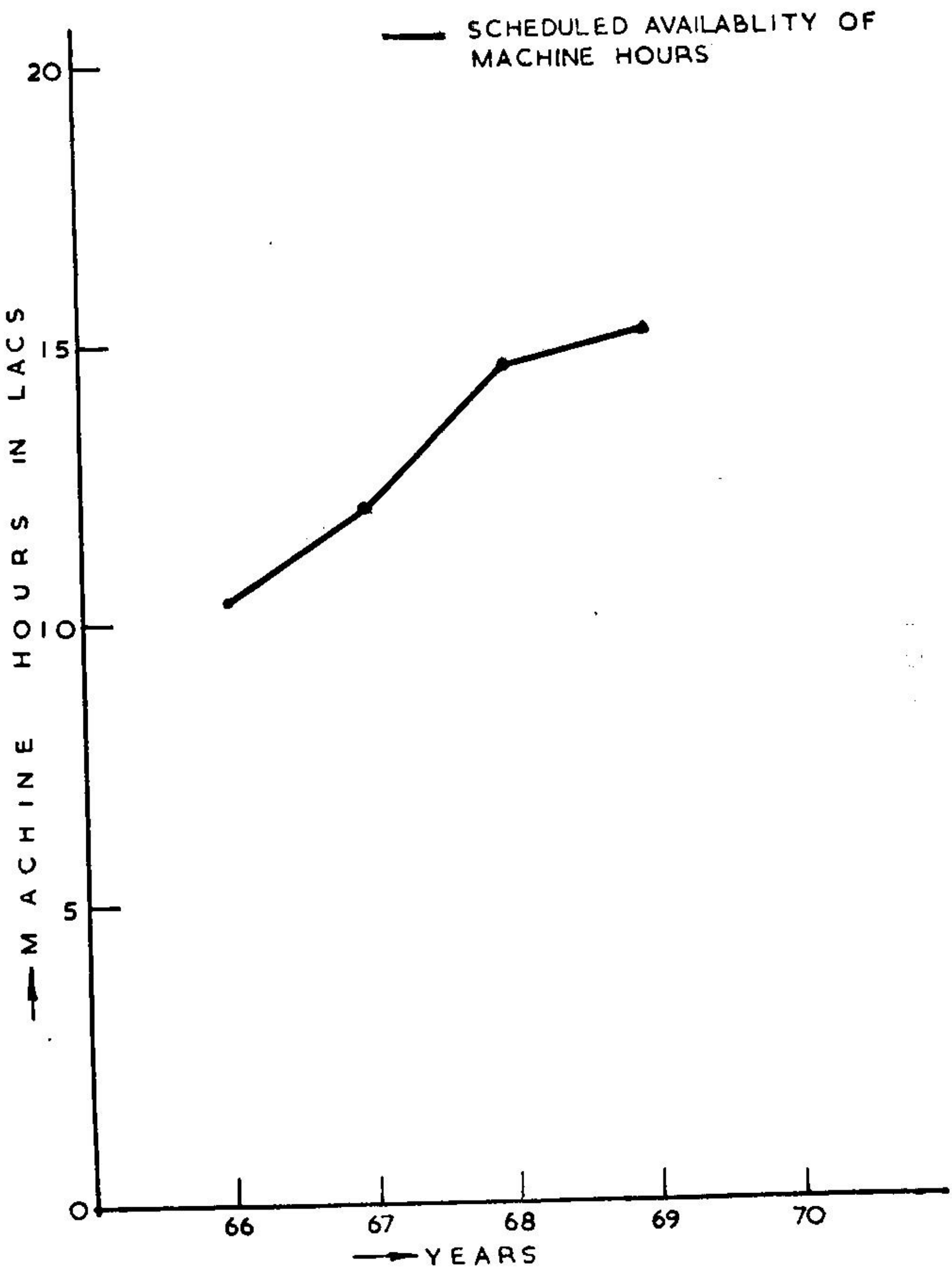

Fig. 1

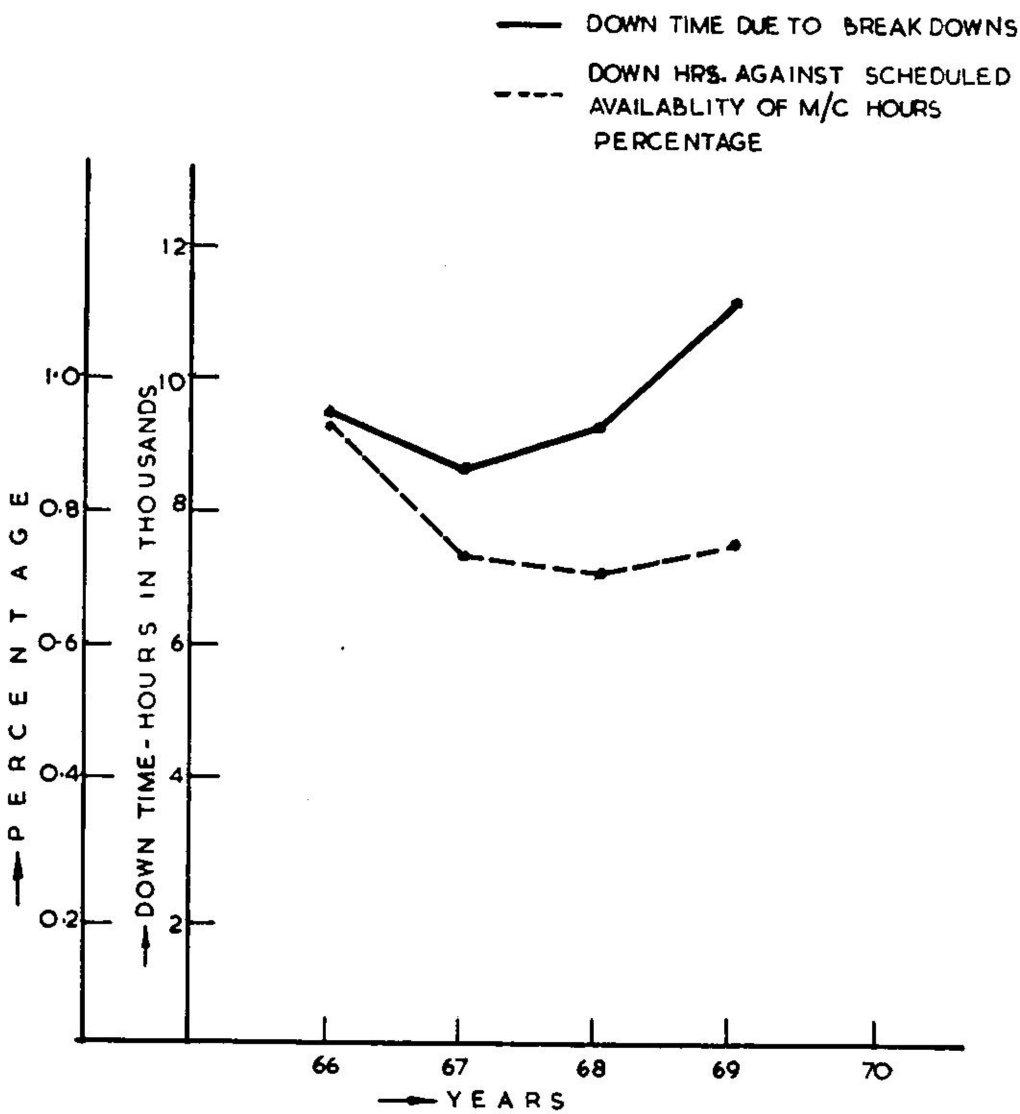
DOWN TIME DUE TO BREAK DOWNS
DOWN HRS. AGAINST SCHEDULED AVAILABLITY OF M/C HOURS PERCENTAGE
PERCENTAGE
DOWN TIME - HOURS IN THOUSANDS
1·0
0·8
0·6
0·4
0·2
12
10
8
6
4
2
66
67
68
69
70
YEARS

Fig. 2

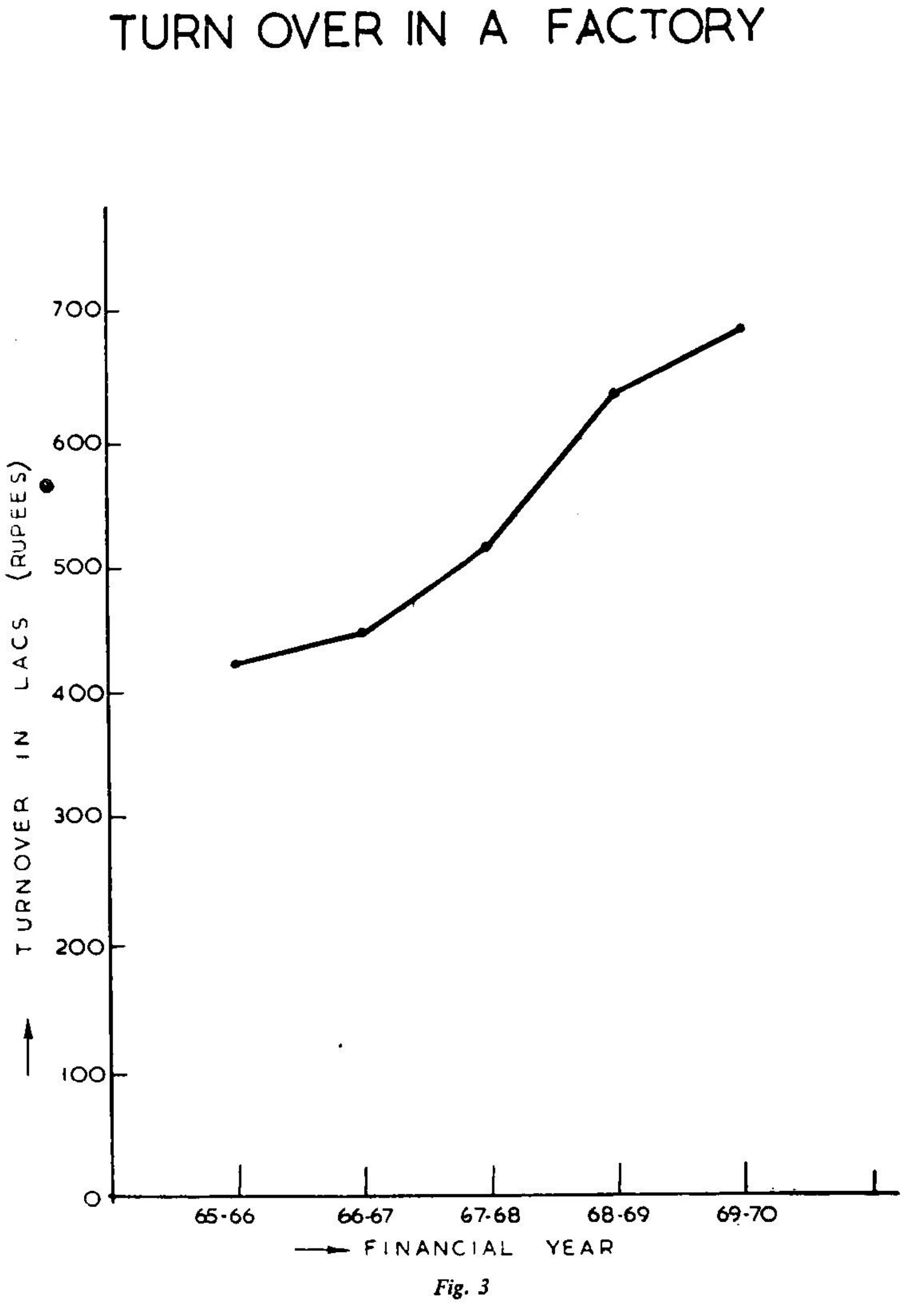
TURN OVER IN A FACTORY
TURNOVER IN LACS (RUPEES)
700
600
500
400
300
200
100
0
65-66
66-67
67-68
68-69
69-70
FINANCIAL YEAR

Fig. 3

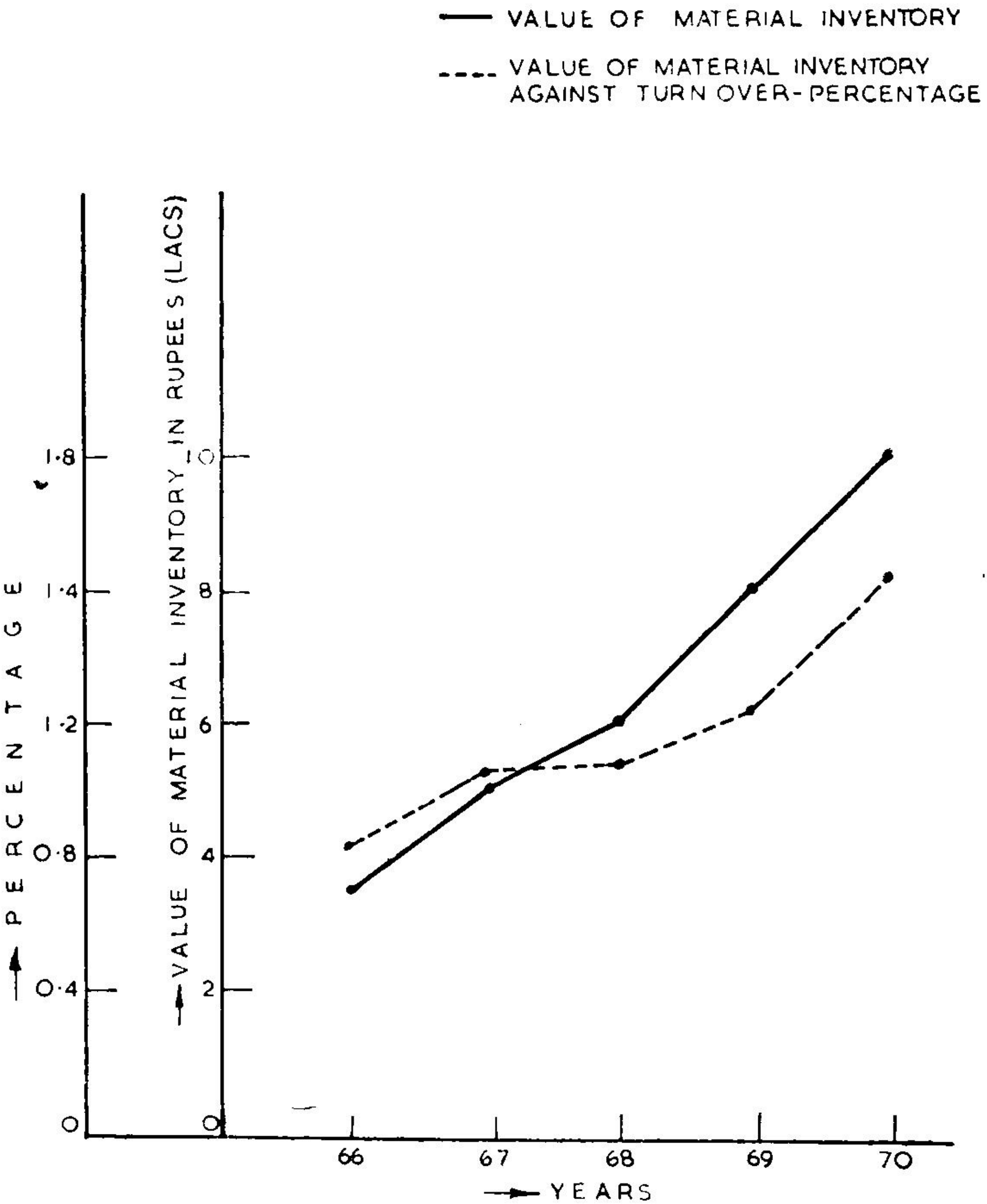
VALUE OF MATERIAL INVENTORY
VALUE OF MATERIAL INVENTORY AGAINST TURN OVER-PERCENTAGE
PERCENTAGE
VALUE OF MATERIAL INVENTORY IN RUPEES (LACS)
0
0·4
0·8
1·2
1·4
1·8
2
4
6
8
10
66
67
68
69
70
YEARS

Fig. 4

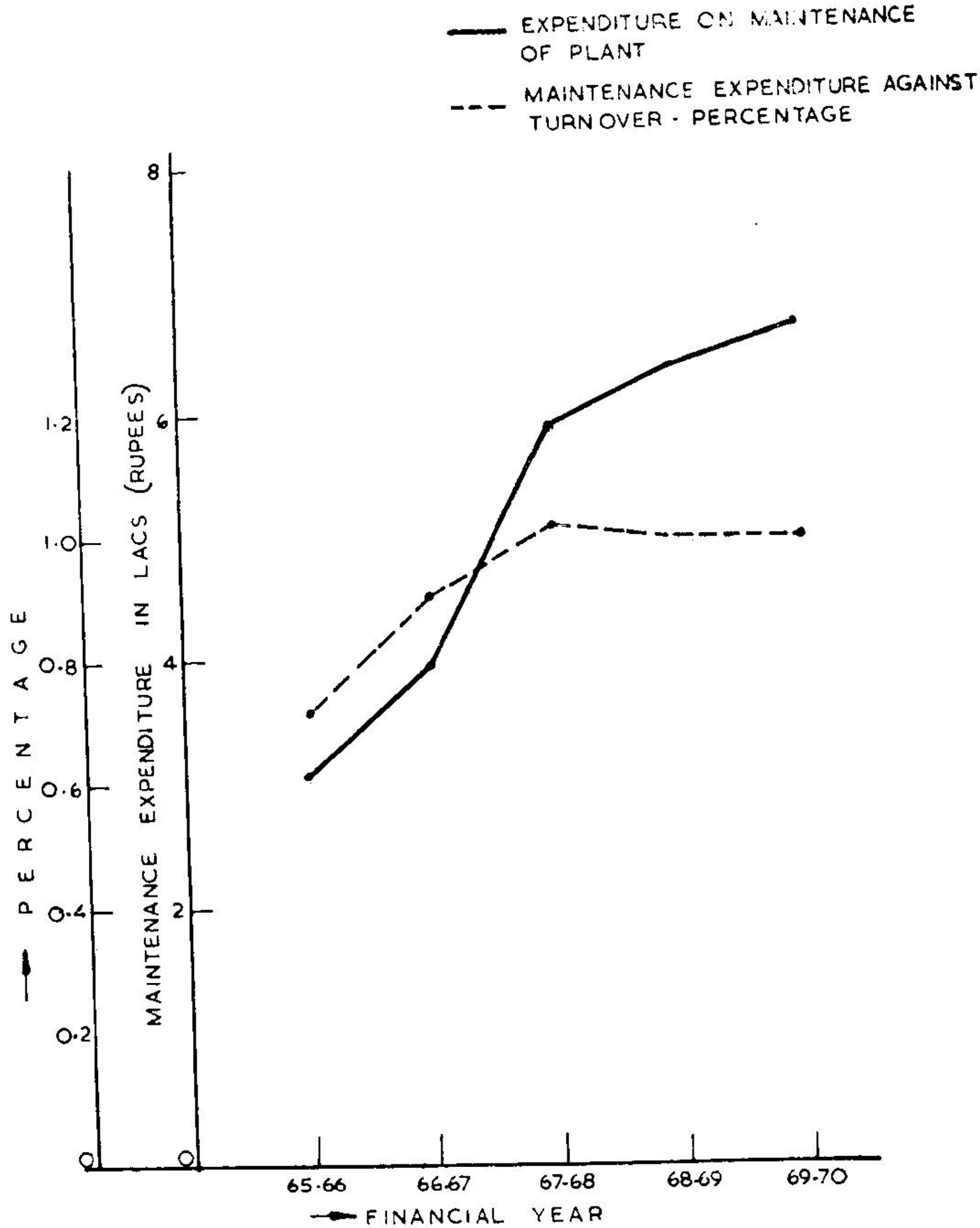
EXPENDITURE ON MAINTENANCE OF PLANT
MAINTENANCE EXPENDITURE AGAINST TURN OVER - PERCENTAGE
PERCENTAGE
MAINTENANCE EXPENDITURE IN LACS (RUPEES)
0.2
0.4
0.6
0.8
1.0
1.2
2
4
6
8
O
O
65-66
66-67
67-68
68-69
69-70
FINANCIAL YEAR

Fig. 5

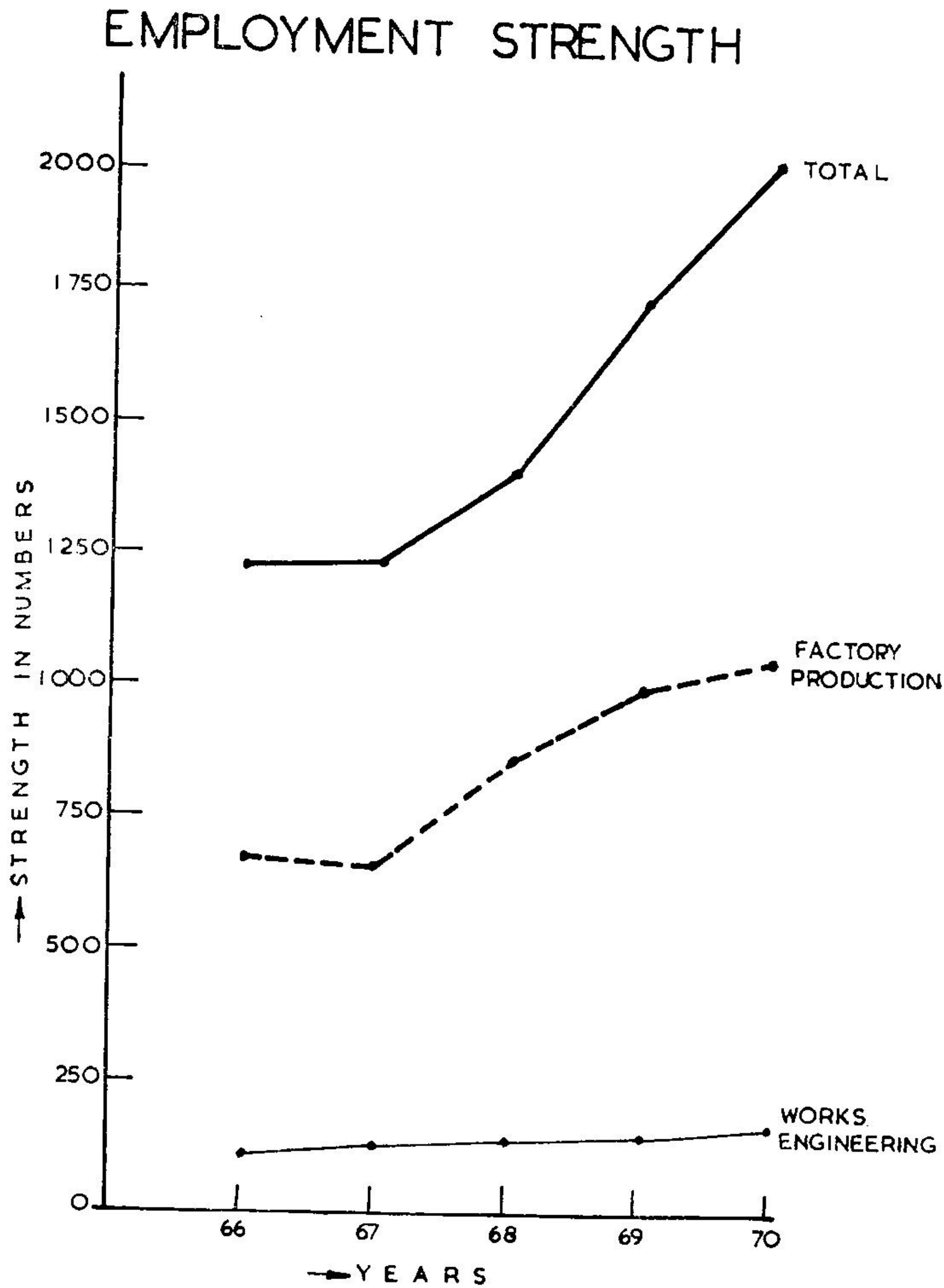
EMPLOYMENT STRENGTH
2000
1750
1500
1250
1000
750
500
250
0
STRENGTH IN NUMBERS
TOTAL
FACTORY
PRODUCTION
WORKS
ENGINEERING
66
67
68
69
70
YEARS

Fig. 6

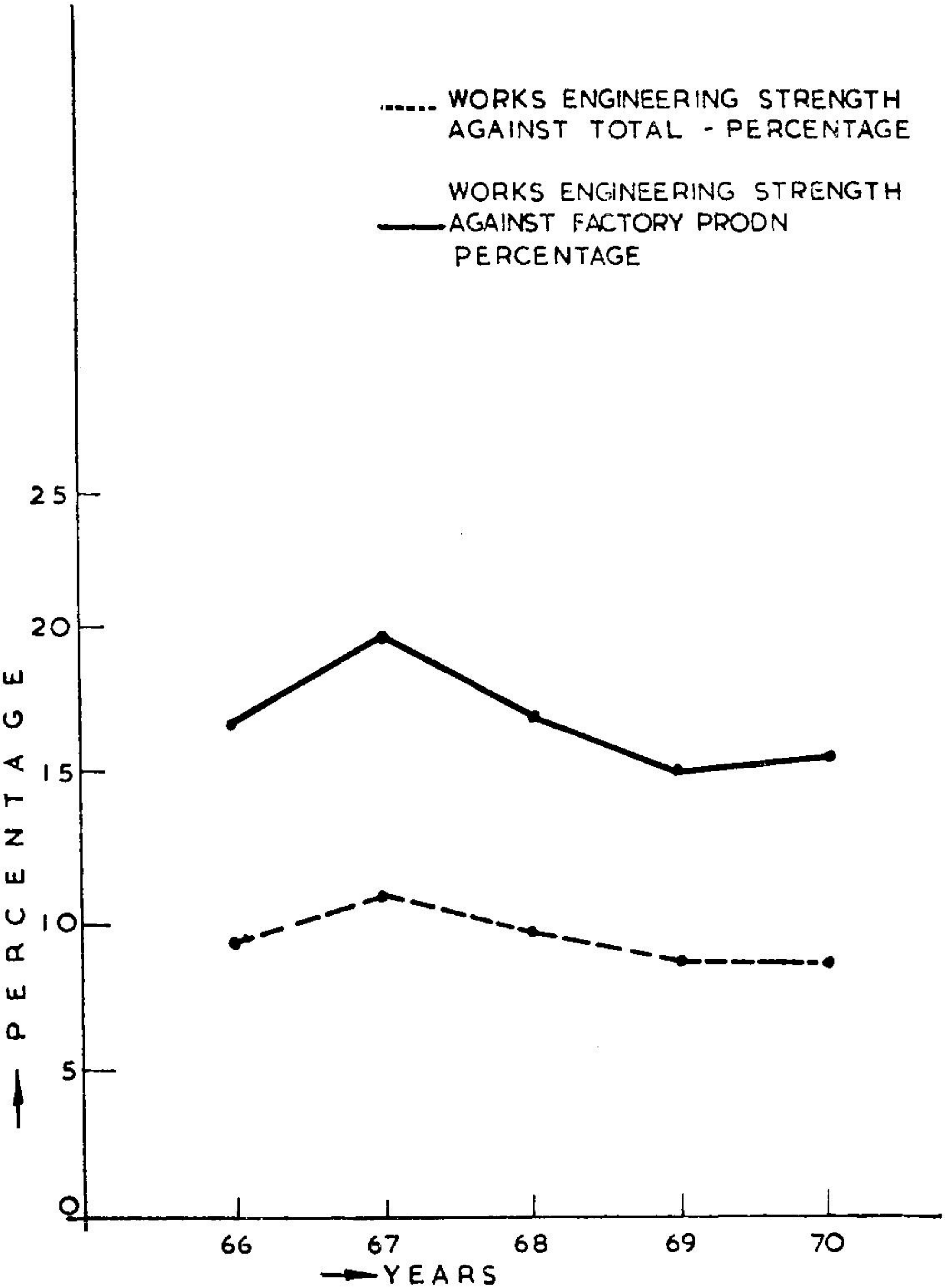
WORKS ENGINEERING STRENGTH AGAINST TOTAL - PERCENTAGE
WORKS ENGINEERING STRENGTH AGAINST FACTORY PRODN PERCENTAGE
25
20
15
10
5
0
PERCENTAGE
66
67
68
69
70
YEARS

Fig. 7

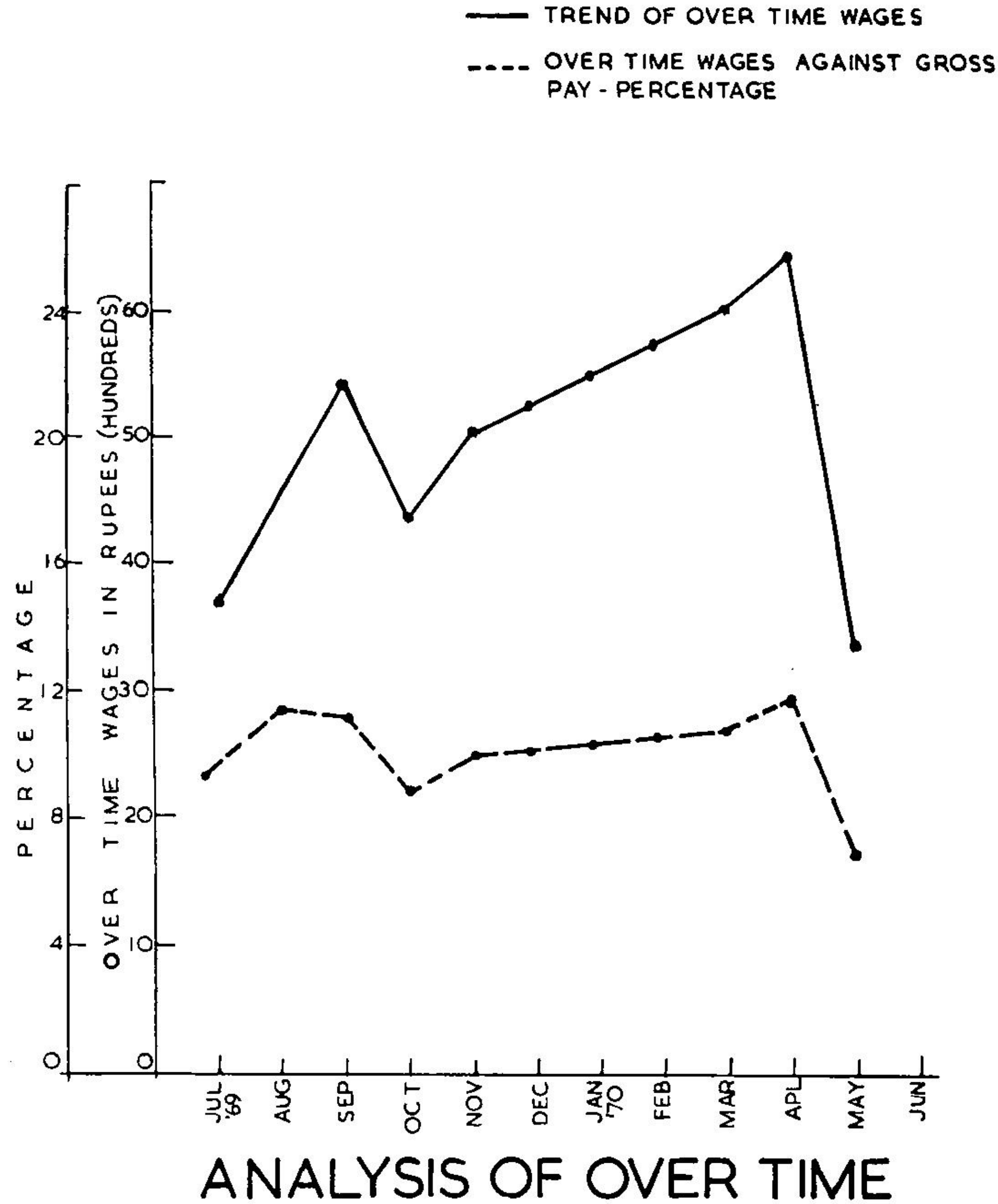
TREND OF OVER TIME WAGES
OVER TIME WAGES AGAINST GROSS PAY - PERCENTAGE
PERCENTAGE
OVER TIME WAGES IN RUPEES (HUNDREDS)
0
4
8
12
16
20
24
0
10
20
30
40
50
60
JUL '69
AUG
SEP
OCT
NOV
DEC
JAN '70
FEB
MAR
APL
MAY
JUN
ANALYSIS OF OVER TIME

Fig. 8

Management of Utilities

S. Govindarajan*

Occupying a key position in the organisational structure of any modern industry, the primary task before the Management of Utilities is to ensure the optimum utilisation, proper maintenance and effective control of utilities - the nerve centre of any productive process. From the point of view of its effectiveness, the management of utilities must be such which permits the full utilisation of all engineering and technological knowledge. Similarly, to obtain maximum results, the management of utilities must endeavour to put forward a militant and agressive programme covering the use of all principles, techniques and tools to effect economy of operations and reliability of services.

Introduction

Utilities form the very foundation of any industry and the importance is known only by their absence. Their management in the modern times has become very scientific. They have assumed tremendous importance in view of the vastly advanced techniques and methods employed and the competitive conditions in the manufacturing cost, necessary for profits today.

The management of utilities in an industrial plant must be one of low cost where all phases of engineering thinking and techniques are utilised to the fullest extent. Utilities and their management occupy an important position in the general organisational structure and covers all aspects of generation, distribution and utilisation. The economy of operation and reliability of service are the two main factors of any utility service. To obtain real results, a militant and aggressive programme covering the use of all principles, techniques and tools must be the responsibility of a wide-awake organisation.

In generation, one must look for the proper location of plant, its availability, economies and patterns of production, demand levels, future expansion programmes, etc.

In distribution, care has to be taken to see that the distribution systems are well laid out with minimum losses, ease of control, adaptable for changes in load and demand patterns, provision for reliable service, etc.

In utilisation, the aspects cover a wide range of subjects such as efficiency of plants, economic operation of machines, reduction of losses, cost per unit of production, etc.

Common aspects of equipment siting, sizing and a host of allied problems are judgement bound. Statutory regulations, safety and human

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aspects have also to be taken into account.

Management of utilities have to be both scientific and humane, able to show profits and yet watchful of the rights of those they manage.

Utilities

Electricity : Electricity has grown to be the most important form of power and the generation, distribution and utilisation of electric power is very vital to every industry. Owing to its flexibility and economy in industrial application and its easy transmission and distribution, large industries and certain types of process industries sometimes find it profitable to generate their own power.

Economic generation of electric power and reliability of service are the indispensable conditions of successful operation of any electrical utility. Whereas efforts have been and are being made towards increased economy and more effective utilisation of equipment, the scheduling of individual generating units on an optimum economy basis has always been one major factor in the overall effort. Long-term and short-term predictions of the power demand to be met and the resources available to meet it are of vital interest.

In industries which require large quantities of low pressure steam and as the economics of steam-raising favour high pressure systems, the excess pressure can be used for electric power generation.

Where the power requirements are high and distances long, high voltage can be used with advantage because of the saving in capital cost and reduced distribution losses. The high voltage cabling can be conveniently taken to sub-stations nearer the load centres and stepped down with transformers and connected to a low voltage gear and then on to departmental distribution boards.

Utilization part of electricity is much easier to control in view of its high conversion efficiency.

Lighting is another important aspect and proper lighting of industrial area increases productivity. Suitable type of lighting and light fittings are to be chosen to provide optimum illumination to avoid fatigue, for example, fluorescent lighting for low roofs upto 6 metres height and high pressure mercury vapour lamps in high bays. Cool colour is desirable for lighting machinery areas. Integrated lighting and air-conditioning system are being increasingly used, e.g., lighting fixture has return air louvres or alternatively for fresh air. Pilot lighting should be provided for safety purposes in case of failure of the mains. Every effort should be made to seek economy in lighting consumption. Power and lighting distribution systems should be segregated.

Measurements of electrical parameters being easy, control over utilisation offers less problems. Aspects such as idle running, speed of machines, power factor improvement, etc., must be considered for economy. Needless to say, the management of this utility has a specific responsibility for the safety of equipment and correct working practices complying with all regulations. Another important point is earthing to ensure safety of personnel.

Water : Water is utilised in most industries for drinking, cleaning, cooling, processing, generation of steam and other requirements in varying quantities and in different levels of purity.

Water may be obtained :

(a) direct from the city water supply,

(b) from wells using submersible or lift pumps, and

(c) from the effluents after treatment.

The water is taken through pipes, mostly underground, to reservoirs and distributed through underground or overhead pipelines. These overhead distribution pipelines have to be painted as per colour code specifications to differentiate and identify the types of water carried.

The amount of water used, especially purchased from outside, is metered and the quantity charged. While considering the utilisation aspects, proper drainage facilities, water recovery methods, etc., have to be taken into account. Maintenance aspects such as corrosion, cathodic protection and painting even before a pipeline is laid have to be considered.

Compressed Air : This is a general utility in many factories which is installed as an automatic system. For compressors, electric drive is most common and it may be either directly coupled or belt-driven. The compressors are of reciprocating, lubricating or non-lubricating type, rotary, centrifugal and other types. The accessories will include inter-coolers and after-coolers, to eliminate most of the moisture in compressed air at the point of use. An air receiver usually serves as an intermediate storage unit to allow for a variable usage pattern and to reduce pressure pulsations.

The distribution of compressed air, generally through overhead lines, needs some attention especially for stopping leaks though it is often neglected. All pipe joints may be welded to avoid leaks and reduce maintenance. The pipes have to be painted as per colour code specifications for identification.

From utilisation point of view, the ease of extension, flexibility of supply points and range of pressures are essential. Since high pressure air is dangerous, statutory regulations and other maintenance requirements have to be met.

Quality of air is important when used for instrumentation and controls and it should be free of moisture, oil, dust, etc. Filters or separators have to be used, depending upon the equipment.

Steam : The supply of steam is indispensable to many industries like textiles, paper, chemicals, etc. for processing and heating.

Increase in steam pressures and temperatures have resulted in improved thermal efficiency and saving.

High pressure steam from which electric power is obtained as a by-product, will serve to meet the demand of process at required low pressures. The importance of steam plant places heavy responsibilities on the management to ensure its reliability. One of the essentials for reliability is maintenance, adequate both in quality and character. Selection and training of maintenance personnel is of utmost importance. Maintenance practices are the practical results of many years of experience and the preventive steps include periodic shutdowns, thorough inspection, replacements, repairs and overhauls.

While converting basic fuels such as coal, oil, etc., into heat for steam production, utmost care has to be taken to recover most of the heat from the fuel. Much of the heat is dissipated in the form of chimney gas, unburnt fuel, conduction, radiation, etc. Waste heat recovery methods such as feedwater or air pre-heating become vital and these improve thermal efficiency. Total energy concepts which take into account all waste heat and recovery methods should be exploited to the fullest extent. Fossi fuelled plants create pollution problems and pollution abatement has become an important aspect.

If furnace conditions and the use of mechanical stokers permit burning,of cheap low-grade fuel resulting in ultimate economy, it should also be tried. Problems of low-grade coal, in-transit pilferage of coal, shortage of coal are to be solved. New boiler installations should go in for equipment suitable for burning low grade coal as high grade coal is made available for metallurgical industries, e.g., in Japan, special spreader type stokers are used extensively for burning low grade fuels. Such problems like back-firing, gas explosion have to be avoided. Feed water treatment of high standard will ensure longer life of plant. Statutory regulations should be adhered to.

Distribution system with well-laid out pipelines, its isolating and control valves, and other constituents such as strainers, traps, etc., require appropriate heat insulation and maintenance. Steam leakages through joints, valves, etc., should be prevented.

Optimum and efficient utilisation of steam should be the main aim, as a high thermal efficiency in generation is not the only indication of economical working. Mechanical extraction of moisture before drying with steam heaters, control of temperatures, air re-circulation, economic loading of heat-consuming plants, using correct pressure of steam, instrumentation and training of operators would result in the better utilisation of steam. Condensate recovery and flash steam recovery should be carried out wherever possible.

Other Utilities

Ventilation, Humidification and Ventilation, Air-conditioning and Refrigeration, Gas Cooling facilities, etc., are some of the other utilities needed by industries.

Ventilation : Proper ventilation has come to pay ample dividends in improved production, better employee relations, cleaner plants and longer productive life.

Exhaust fans have to be used in areas where fumes which are dangerous to persons or corrosive in nature have to be removed.

Humidification and Ventilation: Humidifiers and de-humidifiers are required to control moisture content of air in some industries. Humidifiers may be centrally sprayed, spray-heads at outlets of ducts, steam spray, etc. Evaporative cooling is very often used in place of air-conditioning because of lower costs.

Air-conditioning and Refrigeration : Air-conditioning is needed in industries where dust-free atmosphere and controlled temperature are required, for example, in watchmaking and photofilm industries, instrumentation and computer operation. There are various types of air-conditioning units, employed centrally or separately, depending on the requirements. Loss of heat due to leakages and conduction should be minimised by using automatic door-closers, etc.

Refrigeration for storage, production of ice for process and other uses is also required by some industries.

Maintenance of Utilities

Organisation :

A well-defined organisation, based on universal truths and suited to local situations, staffed by men who understand and appreciate each other's problem and difficulties, is the one most likely to succeed. Some of the basic concepts of a good organisation are:

(a) Reasonably clear division of authority.

(b) Defining of responsibility.

(c) Optimum number of people reporting to an individual.

(d) Type of operation.

(e) Continuity of operation.

(f) Geographical situation.

(g) Size of plant.

(h) Scope of plant maintenance department.

(i) State of training and reliability of work force.

It must be borne in mind that no two plants are alike and their differences will necessitate modifications in emphasis within the same basic organisational structure from one plant to the next.

Principles and Scope of Organisation :

The basic principles are :

(a) To maintain a plant at a level consistent with low cost and high productivity.

(b) All personnel to be selected and trained, if necessary, according to the duties and responsibilities involved.

(c) Consideration given regarding the status of the personnel in the organisation.

(d) The modern complex, sophisticated and automatic machinery need modern engineering techniques and skills.

The organisation establishes the authority, responsibility and relationships to effectively obtain the objectives of the organisation.

The scope of the organisation may be broadly classified as primary and secondary functions. The primary functions are :

(i) Maintenance of existing plant equipment.

(ii) Maintenance of existing plant buildings and grounds.

(iii) Equipment inspection.

(iv) Utilities generation and distribution.

(v) Alterations to existing equipment and buildings.

(vi) New installations of equipment and buildings.

The secondary functions will be :

(i) Store-keeping.

(ii) Plants protection including fire protection.

(iii) Waste disposal.

(iv) Salvage.

(v) Insurance administration.

(vi) Property accounting.

(vii) Pollution and noise abatement.

(viii) Any other service.

Policies with regard to the operation of the organisation, work allocation for scheduling, determining priorities, preventive engineering, own work-force and outside contractors, centralised or decentralised maintenance, recruitment, training, communications, standard practices, cost control systems, responsibility for safety etc., are all to be clearly brought out and considered.

Maintenance :

The maintenance of plant utilities is though considered by many as necessary evil, the cost of labour, spare parts and plant downtime can be substantial and the only reason every such expenditure is incurred is that the alternative costs in terms of plant failure, emergency work, and safety hazards can be even worse.

The basic function of maintenance can be summarised as the accomplishment of all work necessary to establish and maintain the facility and its equipment in a condition to meet normal operating requirements. This function can be broadly subdivided into :

(1) Inspection.

(2) Preventive maintenance.

(3) Repair.

(4) Overhaul.

(5) Construction.

(6) Application of industrial engineering techniques.

(7) Salvage.

(8) Administration for actual direction and supervision of the work functions.

1. The maintenance inspection involves the periodic inspection of machinery and equipment to ensure safe efficient operation: equipment requiring work at specified periods receives proper attention, examining of items removed during maintenance and overhaul operations to determine feasibility of repair, inspection of maintenance items received from vendors and control of the quality of work accomplished by miantenance groups.

2. Preventive maintenance work is confined to checking, adjustment, routine replacement, lubrication and clean-up necessary to make certain that the facility and its equipment are in proper condition and ready for use. This maintenance work is predictable, readily adaptable to accurate planning and scheduling. Preventive maintenance is the area where maintenance can effect the greatest savings in overall manufacturing and operating costs.

The service engineering group functions are to develop the information with regard to jobs, planning and scheduling the work, establishing the preventive maintenance schedules, establishing the record for corrective service, follow up and analysis of such records for engineering improvement, and establishing charts and data for improvement and correction.

3. Repair is that unscheduled work, often of an emergency nature, necessary to correct breakdowns including trouble calls. However with an adequate preventive maintenance programme there should be little of this work.

4. Overhaul is considered as the planned, scheduled reconditioning of facilities and equipment. This work will involve one or more of the elements of teardown, examination, replacement, reconditioning, reassembly and testing.

5. Construction jobs are undertaken as a basic policy by some companies, as part of the maintenance, for works such as electrical installation, plumbing, building, steel construction and so on. Also contracted construction work depending on the magnitude of the work forms the policy of the company.

6. Salvage or reclamation and disposition of scrap or surplus material also form a part of maintenance procedure. The handling of scrap is closely related to the maintenance clean-up and house-keeping function.

Selection and Training:

The need for proper selection of men and training of personnel need not be overemphasised.

A sound selection of personnel will result in lowering the maintenance costs, lowering the turnover of manpower, lowering cost of maintenance training, eliminating lower standard of trade and improving employee morale.

Maintenance Manual :

The Manual can be an effective medium and is a basic device for training or re-training personnel in the use of equipment, techniques, maintenance functions, etc. It will outline the maintenance management of the organisation, standard methods for accomplishing maintenance and repair of plant, facilities, etc., and a sound maintenance programme.

Paper Work :

Paper work is a must for proper functioning and control of maintenance operations. There should be neither too little nor elaborate paper work but every form should play an important part in the control of personnel, costs or jobs.

Equipment Records:

Work orders, standing work orders, time cards, maintenance store room control cards, preventive maintenance inspection forms and schedules, downtime reports, long-range capital work orders, emergency break-down and repair orders, overtime reports, request for engineering services, monthly reports, are most of the important paper work items needed for effective and efficient control.

Standards :

Maintenance standards are used for planning and scheduling maintenance work, providing a properly-sized maintenance force, measuring the effectiveness of the maintenance crews and providing incentive earnings for the maintenance personnel.

The standards may be established by the application of industrial engineering methods.

Lubrication :

Any machine will operate most dependably when it is properly lubricated. It is essential therefore that lubrication is properly maintained and that lubricants most suited to the operating and constructional conditions are used. Lubricant of the right quality, used in the right quantity and lubricated in the right time lead to minimum cost of maintenance and low-cost production. A clear and well set procedure must be laid out for lubrication.

Buildings :

Whitewashing of buildings as per Factory Act, drainge and storm water drains, painting of structures, repairs to roadways, floors, roofs, etc., all fall in the regular maintenance pattern of the organisation.

Fire Protection :

The control over fire protection service, the use of various types of fire extinguishers as well as water spraying dependent upon the type of fire and location, the maintenance of fire hydrants, hoses, nozzles and accessories calls for routine and vigilant periodical checks and tests.

Material Handling :

Material handling facilities such as cranes, hoists, chain blocks, monorails, lifts, etc., are required for transportation. These are important service facilities. They should be liberally proprotioned to carry the loads.

Most important aspect in the management of these is safety. Frequent inspection of weak points and immediate attention are the essential maintenance activity on these.

House-Keeping :

The quality of house-keeping in an industry is an excellent indication of the efficiency of its operation and of the effectiveness of maintenance. Factors governing good house-keeping are proper layout, correct material handling and storage, cleanliness and orderliness. Good house-keeping and profitable operation go hand in hand.

Control Aspects of Utilities

Budgeting and Cost Control :

A budget is an estimate of the forecast of expenditure needed for the cost of performing work in future period. The types of budget are: first, which forecasts the cost of maintaining equipment in satisfactory operating condition; second, which forecasts the cost of operating certain service departments ; and third, the operating budget. A well-defined and balanced maintenance budget will ensure the successful operation and development of a confident and capable maintenance organisation of high standard, cost control is of paramount importance.

The major expenses that a maintenance organisation will incur are :

(a) Additions to Capital.
(b) Repair and maintenance expense.
(c) Dismantling expenses.
(d) Cost of producing and distributing utilities like electricity, steam, water and compressed air, etc.
(e) Miscellaneous expenses.

The good results that will be gained due to an efficient cost control are :

(1) A means to correct and improve.
(2) Use of engineering methods and techniques for cost reduction.
(3) Maintenance of plant in good operating condition at a minimum cost.
(4) Provide a basis for a sound preventive maintenance programme.
(5) Means for planning and scheduling all maintenance work.
(6) Determine cost of all maintenance jobs.
(7) Aid to the improvement of the productive equipment.

Inventory Control :

The quantity of materials stocked should be maintained at its most economical level through astute inventory planning, and using all modern techniques like economic order quantity, ABC analysis of items, etc.

Centralised and de-centralised stores each has its own advantages and disadvantages with regard to control systems, cost accounting, number of personnel required, usage of space, handling, waiting time for craftsmen, supervision required, etc. But the actual requirement will vary according to the size, nature and location of maintenance sections.

The main aims should be to develop an effective procedure and stores and related functions to assist in minimising total maintenance cost. One of the most effective methods is to standardise the equipment and materials used.

Project Control :

It is organising, budgeting and putting into operation and controlling certain industrial construction work which may embrace a variety of crafts and equipment. New work and alterations are two major divisions of projects depending upon the company's policies.

It needs preliminary planning, budgeting and tentative approval at the outset. Once it is approved, in organising and completing a project the procedure will be in the order of :

(a) Project design.
(b) Preparation of detailed cost estimates.
(c) Preparation of appropriation requests.
(d) Establishment of labour requirements.
(e) Setting up of target dates.
(f) Preparation of master schedules or network.
(g) Establish running check lists.
(h) Record systems.
(i) Report systems.
(j) Determination of supervisory and staff requirements.

Other Control Aspects :

Cost of production will provide a guideline for comparison with other similar units producing the same utilities. Transmission and distribution losses can be assessed by quantities produced and utilised. An idea of utilisation efficiency can be obtained by recording quantity of steam, electricity, water, etc., used per unit quantity of production. Variance from the normal pattern can be deeply probed. Graphs can be maintained to note the variance with the production patterns. Random checks can be conducted on systems to obtain the operating efficiency of the plants.

Instrumentation, automatic controls and servo-mechanisms play important role in effective control of the utilities. Six important approaches for control are: electrical, hydraulic, optical, pneumatic, fluidic and radio-isotopes, these being used separately or in various combinations.

Conclusion

The subject "Management of Utilities" is vast and wide and the factors involved are so variable that it may not be possible to go in detail into every aspect. However, an attempt is made to cover the important points and broad-based ideas in this article. □

"The mere lay-in of a core of capital equipment, indispensable as that is for further economic expansion, does not yet catalyse a tradition-bound society into a modern one. For that catalysis to take place, nothing short of a pervasive social transformation will suffice, a whole metamorphosis of values concerning time, status, money, work and an unweaving and reweaving of the fabric of daily existence itself,"

—Robert Hellbroner

Overcoming Hazards in Chemical Industries

A.K. Pratap Singh*

The two most potential hazards to industrial safety in chemical industry are the toxic substances or industrial poisons and fire and explosions. Overcoming these hazards must be taken as a challenge by the safety engineers in the chemical industry. Control of the environment by using less toxic materials, by providing general and local exhaust ventilation, by isolating and enclosing certain processes of highly toxic substances could, to a great extent, fight these hazards. At the same time, personal protective devices such as goggles and face shields, protective clothing, respirators and preventive creams and lotions should be provided to the workers for their personal safety. Last but not the least, comprehensive training programmes on industrial safety and personal hygiene must be developed to educate workers.

Due to the diversity of the Chemical Industry, both in scale and processes and substances handled, the formulation of a detailed code of practice covering all hazards in Chemical Industry would be impossible in the space of a short article. The hazards arising out of the use of various chemicals can be classified into two groups :

1. Toxic substances or industrial poisons,
2. Fire and explosions.

In this articale an attempt is being made to identify the hazards associated with the toxic substances and the methods of overcoming or minimising the hazards in general.

The chemicals used or produced in an industrial operation generally disseminate into the air. These can be classified according to their physical states as follows :

A. Gases and Vapours :

Sulphurdioxide, carbon monoxide, hydrogen cyanide, and chlorine, gases and the vapours of trichloroethylene, benzene, xylene etc.

B. Particulate matter :

i. Dust: These are solid particles produced by grinding, crushing, drilling and blasting operations and are suspended in the air. The sizes of the particles are predominantly higher than 0.2 micron.

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ii. Fumes : These are solid particles generated by condensation, generally after volatilization from melted substances and often accompanied by oxidation. The particle size varies from 0.2 to 1 micron. Common examples are lead and zinc fumes.

iii. Mists : Dispersion of liquid particles in air. These are generally formed by the condensation of water vapour on sub-microscopic particles or by the atomization of liquids. Mist of sulphuric acid is an example of this dispersion.

iv. Smokes : Small gas-borne particles (diameter is less than 0.3 micron) resulting from incomplete combustion and consisting predominantly of carbonaceous material are grouped in this category.

Apart from these, the air contaminants may be present in forms of smog and fog which are also usually encountered in industrial environment.

Avenues of Entry of Toxic Materials

The chemical contaminants enter human system mainly through three avenues : inhalation, absorption and ingestion.

A. Inhalation : Inhalation is by far the most important route of intake of the airborne contaminants. In an industrial environment various substances, solid, liquid or gaseous dissipate into the air In the process of breathing, these air-borne contaminants come in contact with the respiratory system, and some contaminants eventually find their way into the lungs. Thus the respiratory system serves as the portal of entry into the body for a great variety of air-bone substances, both gaseous and particulate. Many of these contaminants are capable of producing injury and disease when they are deposited and accumulated in sufficient amount in the lungs.

B. Absorption through the skin: Many gaseous and liquid materials are absorbed to a limited extent through the in-tact skin by way of the air-spaces in the hair follicle to the glands and gland-cells. Appreciable skin absorption occurs with certain liquids of low volatility. Phenol, cresol, nitro-benzene, aniline tetraethyl lead, and many of the organic phosphate insecticides, such as parathion and TEEP are liquids that present an equal or greater hazard through skin absorption than through inhalation. Absorption through lesions of the epidermis is much more rapid than through the in-tact skin. However, hydrogen cyanide, for instance, passes through the unbroken skin if enough quantity is present in the air. Absorption through the skin is less common with solids.

C. Ingestion : Ingestion of toxic materials may result from many sources such as contaminated food, beverages, or from putting fingers or other contaminated objects into the mouth. Ingestion of toxic substances along with food, in workrooms, where the housekeeping is not good or where workers are careless, is common. Compared with inhalation, ingestion however, plays a minor role in the absorption of toxic materials in industry.

General Effects of Industrial Toxic Materials

In an industry the worker has to undergo physical exertion, depending upon the nature of work. Physical exertion creates an immediate demand for oxygen, resulting in stimulation of breathing. The volume of air breathed per minute varies with the activity. Similarly, the rate of inhalation of any toxic impurity in the air increases with increase in exertion.

Ingested material usually passes directly into the intestine from the stomach and is often eliminated without being taken into the blood stream. For this reason, many substances, such as lead compounds, are more toxic when inhaled than when ingested.

Many of the poisonous elements can, however, be stored for long periods of time in the body. Metals, such as lead, radium, and non-metals, such as fluorine, can be stored in the bones. Mercury is also stored in various parts of the body. If further absorption of the toxic elements is discontinued, excretion of the stored portion is begun until it is virtually eliminated from the system. Otherwise if there is a long continued intake of some toxic substances, excretion may increase until it balances absorption. This is frequently found in chronic poisoning.

Industrial poisoning is of two main types, acute and chronic. The first is induced by large doses of poisonous substances and the latter is the result of repeated or continuous small doses. In an industrial environment, the conditions causing chronic poisoning are more apparent and significant than those causing acute poisoning.

There are three types of acute effect which may result from inhalation, particularly of gases and vapours. These are asphyxiation, irritation of respiratory organs, and narcosis.

Other responses which are more typically chronic in nature include damage to lungs, blood, nervous system, liver, kidneys, bones, skin etc. A few examples are cited:

i. Inhalation of dust containing free silica will produce silicosis among the exposed personnel.

ii. Benzene, arsine and lead have been found to produce blood changes. Organic posphates destroy the enzyme, cholinestorase, which is present in red blood cells.

iii. Carbondisulphide, and some of the halogenated hydrocarbons have a cumulative effect upon the nervous system. Chronic mercury and manganese poisoning usually affect the nervous system.

iv. Injury to liver and kidney is noted from industrial poisoning involving arsenic, carbon tetrachloride, phosphorus, etc.

v. Chronic poisoning from yellow phosphorus and fluorine causes serious damage to bone structure. Cancer frequently develops in bones in case radium is deposited.

vi. Skin affection in the form of dermatitis may be attributed to the skin absorption of tetraethyl lead, trichloroethylene, cutting oils, etc. Skin cancer is caused by long continued contact with certain constituents of coal tar and shale oil.

vii. Bladder tumours are caused when chemical carcinogens, such as betanapthylamine and benzidine, are inhaled over considerable time. Radioactive substances also produce tumours, cancer of the lung being attributed to the inhalation of radium, chromium salts and chromic acid.

Permissible Limits

In an industrial environment the optimum goal to be sought is zero concentration of the air-borne contaminants. However, it is neither practically feasible to eliminate all the contaminants completely nor it is necessary to do so. Hence certain concentrations may have to be tolerated. The question is, to what extent the presence of toxic substances may be allowed without any adverse effect ?

The threshold limit values refer to air-borne concentrations of substances and represent conditions under which nearly all workers may be repeatedly exposed without adverse effect. These limits should be used as guides in the control of health hazards and should not be regarded as fine lines between safe and dangerous concentrations. Threshold limits are based on the information from industrial experience, from experimental human and animal studies or from a combination of the three.

Most of the values are based on the time-weighted average concentrations, i.e. average concentration for an 8-hour working period. A few examples are: Benzene-25 ppm, Hydrogen chloride-5 ppm, xylene - 200 ppm, carbon disulphide-20 ppm, cyanide-5 mg/m^3, mercury-0.1 mg/m^3 etc.

Appraisal of Health Hazards

In evaluation of environmental conditions in order to get an overall picture in determining occupational health hazards, information is to be sought on the following:

i. Nature of substance or exposure;

ii. Intensity or severity of exposure;

iii. Length of exposure ; and

iv. Personal susceptibility.

The toxic nature of the substance and the factors relating to workers' potential exposure at various periods are to be noted in environmental surveys and studies. A sufficient number of samples should be collected for proper duration to enable the calculation of workers' weighted exposure to dusts, fumes, mists and vapours.

Expression of Results

The chemical air-borne contaminants present in an Industrial environment are always in minute quantities. The units in which the concentrations are expressed are usually ppm (parts per million parts of air), mg/m^3 (milligram per cubic meter of air), and in the case of dust the unit is MPPCF (million particles per cubic feet of air) or particles per cc. (MPPCF x 35.3 is equal to particles per cc). All the results are based on concentrations of contaminants in normal atmospheric pressure at 25°C.

Control of the Environment

The objective of the control of the environment is to eliminate or reduce the hazardous substances. These can be accomplished by means of one or a combination of more than one of the following methods.

1. Substitution of Less Toxic Material : In any process where potentially hazardous materials are used, the possibility of substituting less toxic materials, or change in the process should always be considered. This has been achieved in industry to a certain extent. Less toxic solvents, such as methyl chloroform, trichloroethylene, have been used successfully as substitutes for highly toxic carbon tetrachloride. The use of less toxic xylene and toluene in place of highly toxic benzene has increased.

Sometimes, change in the process can be made to reduce the exposure to injurious materials. Steel shots are gradually replacing sand for abrasive cleaning operations. Carborundum and alundum are used as abrasive materials instead of sand-stone. The application of paints by brushing instead of spraying is another example of process change.

2. *Isolation and Enclosure* : In the manufacture or processing of highly toxic substances such as tetraethyl lead or beryllium, the entire operation is isolated in a carefully sealed-off area. All personnel involved are equipped with personal protective equipment and are trained thoroughly in safety practices. There has been a thorough application of this method in the manufacture of explosives. In the chemical industry, the isolation of hazardous processes is sometimes an essential necessity.

Many processes can be completely enclosed during all or part of the operation, and when maintained under a negative pressure, will prevent escape of contaminants into the workroom atmosphere. Examples are, shot blast machines for cleaning castings, modern drum and bag filling equipments, and bottle filling chamber for parathion. Enclosure is also a method of controlling exposures from such operations as sand-blasting, mixing, grinding and heat-treating. Sometimes a partial enclosure combined with exhaust can be applied.

3. *Use of Wet Methods* : High reduction in dust concentrations in rock drilling operations have been achieved by the use of water forced through the jack-hammer. Wet methods have been used in many foundries where water under high pressure is used for decoring operations instead of chipping. It has also been found that air-borne dust concentration could be brought down if the moulding sand is kept moist and if castings are wetted before knockout operation.

4. *Local Exhaust Ventilation:* The principle employed in this method is to remove the atmospheric contaminants at the point of generation or dissemination. This is one of the most important of engineering methods of environmental control. Local exhaust ventilation is by far the best method of preventing air contamination where contaminants are given off from operations or processes confined to relatively small areas. These include grinding and buffing, hot process tanks, ovens and furnaces, plating and dip tanks, spray painting, and various kinds of mixing and blending operations.

For an effective performance of this system, all equipment require systematic checking and maintenance. Common defects include failure to trap and carry away all the contaminants, ducts subject to plugging and choking, incorrect air velocity, air turbulence, etc.

A detailed discussion of various principles involved in the design of local exhaust ventilation is beyond the scope of this article. However, certain salient points are mentioned.

a. To be effective, the air flow to the exhaust duct must include the entire area liberating the contaminants.

b. The shape and size of the hood, its position and the capture velocity should be such as to trap all the contaminants produced and to carry them into the exhaust duct.

c. In the case of ducts, the minimum air velocity in the ducts must be maintained to prevent settling.

d. The air flow should be away from the breathing zone of the operator.

e. Stack suction should sometimes be aided by forced draft. The air exhaust from production processes may be discharged from stacks carried well over the building roofs : otherwise, the exhausted air along with the contaminants may be transfered back to the plant through the windows or other openings. Aerosols in the exhausted air are to be collected by means of suitable collecting equipment before it is let out. The common types of collectors are cyclones, bag or cloth filters, air washers and electrostatic precipitators.

In cyclone collectors, separation of particles from air stream is achieved by the action of centrifugal and kinetic energy imparted to the dust particles by the radial velocity. Cyclone collectors, however, are not effective for very fine particles.

In the bag filter, the air is passed through fabric filters with provision for collection of the trapped dust. The collected dust is usually loosened by shaking or jarring the framework supporting the bags.

Air washers remove dust by thoroughly wetting it. Dust-laden air is passed though a series of passages, continuously drenched with a fine spray of water. The dust is either carried off in the stream of water or collected in a basin as sludge. The method is effective with heavy or water-soluble dusts.

In the electrostatic precipitators, dusts, particles and acid mists are electrically charged and thus are attracted to an oppositely charged object or surface. Collection efficiencies upto 99 per cent have been achieved in the collection of fine particles.

The electrostatic precipitators have been successfully used in the following industries : thermal power, metallurgical, cement, paper and chemical.

5. *General Ventilation*

General Ventilation or dilution ventilation entails the use of natural convective currents through open doors or windows, roof ventilators, chimneys or artificial and mechanical ventilation. The term implies changing the air throughout the entire room or building. General ventilation will be effective if the degree of air contamination is not excessive, and particularly if the contaminant is released at substantial distance from the breathing zone of the workers. Otherwise contaminated air will not be diluted sufficiently before inhalation.

The American Foundrymen's Association, in its Code of Recommended Practices, suggests that natural ventilation should be relied on only if the gross cubical content of the workroom having only moderate sources of air contamination from the limited use of low hazard substances is 2,000 cubic feet or more per person. Dilution ventilation, however, is not generally recommended for dusts or fumes.

Dilution ventilation, is used most successfully to control vapours from low toxic organic liquids. In order to calculate the amount of ventilation air required to dilute a given contaminant to a safe level, factual data are needed on the rate of vapour generation or on the rate of liquid evaporation.

General ventilation rates are often expressed in such units as "air changes per hour" or "minutes per air changes". These units express the ratio of the volume of air supplied or exhausted to the volume of the room. For purposes of control by dilution, however, such terms are of little value. Air changes per hour are dependent on the size of the room, while the quantity of air needed to dilute a contaminant generated at constant rate is not affected by the size of the room. Hence dilution ventilation rates should be expressed by cubic feet per minute or any other absolute unit of quantity flow.

6. Personal Protective Devices: Personal protective devices should always be used as last resort and should not be depended upon if the air contaminants can be eliminated by the methods discussed in 1 to 5 above. These devices do not reduce or eliminate the hazard. They merely provide a guard or defence between the contaminants and the exposed individual. Any failure of the defence means immediate exposure to the hazard.

These devices providing protection against chemical hazards may be divided into four groups :

i. Goggles and face shields;
ii. Protective clothing;
iii. Respirators and
iv. Preventive creams and lotions.

i. Goggles and Face Shields : These are used to protect the eyes and face from corrosive solids, liquids and foreign bodies. Goggles are also used for protection against eye injury, resulting from welding, flame cutting and melting operations. The important point is to choose the correct type for the specific job and insist that the worker wears the goggles or face shield while on the job.

ii. Protective Clothing : Gloves, aprons, footwear and impervious coveralls are used to prevent the body from contact with a host of corrosive materials. These devices have played an important part in the prevention of dermatitis and it has been recognised for many years. One of the problems is, however, to choose the correct article for a specified application. For example, one type of rubber gloves will afford ample protection against trichloroethylene and carbon tetrachloride but will become spongy and will eventually disintegrate in contact with lacquer solvents

iii. *Respirators* : Respirators can be divided into three general types :

1. Mechanical filters for protection against dusts and some specific particulates;
2. Chemical cartridges for protection against toxic gases, vapours and fumes;
3. Airline or supplied air respirators for protection against conditions immediately hazardous to life.

In general, each type of respirator is designed for protection against specific toxic materials. Choice of the proper respirator for the specific contaminant is, therefore, most important consideration. For example, dust respirators should not be used for protection against carbon tetrachloride vapour, or lead fumes. In selecting respirators it is important to see whether these meet the specifications. Certain specifications have been laid down by U.S. Bureau of mines.

It is, however, worthwhile to remember that the respirators have two drawbacks in common: they are more or less uncomfortable to wear and they reduce the worker's efficiency to a certain extent.

Hence the common complaint is the reluctance on the part of the worker to wear them. It is, therefore, much profitable in the long run to eliminate the hazards by any of the methods discussed earlier.

A successful respirator programme entails education of the worker on reasons for wearing these devices and instruction on their proper use.

iv. Protective Creams and Lotions : There are some barrier creams and lotion preparations for the protection of the skin. This type of protection may sometimes constitute a worthwhile aid to prevention of skin diseases if the preparations are properly selected and correctly used.

7. *Maintenance, Housekeeping, Education and Personal Hygiene*

These four items are interdependent. It is impossible to have satisfactory maintenance unless the housekeeping is good and the worker has been educated regarding the need and methods of achieving these principles. For example, if the thermostat on a degreaser fails or is accidently broken, excessive concentration of trichloroethylene might quickly build up in the work area, unless repairs are made immediately.

Housekeeping is also an important control measure. If the toxic dust accumulating on the floors, machines, and ceilings are not periodically cleaned, many more workers may be exposed to hazardous concentrations. Education of the workers, likewise, is very essential, if all the control measures for the health and safety of the workers are to be effectively implemented. Personal hygiene, such as frequent use of soap and water by the workers, is the most important method for reducing the incidence of skin diseases. Workers should always be encouraged in the practice of good personal hygiene by the provision of adequate washing facilities, lockers and change rooms.

In the final analysis human behaviour is at the root of most accidents. Complacency, haste, inattention to instructions and directions lead to mistakes and accidents. It is said that 90% of all industrial accidents are due to human failures—direct or indirect. It is, therefore, essential that engineers and supervisory staff who man the plants are fully conscious of the principles of occupational safety and health. Organised compaigning and sustained efforts directed towards overcoming the possible hazards in the various spheres of activity, such as design, construction, production, better house-keeping and safer materials handling programme will bring about better results.

Operational Problems in Fertilizer Industry

P.L. Kukreja*

One of the major bottlenecks in the production of fertilizers in our country has been the frequent failure of power supply resulting into mechanical and thermal shocks to the process equipment, damage to refractory lining of the reactors of the furnaces, leakages in steam and gas lines and choking of the pipe-lines, to mention only a few. Transmission at high tension, provision of automatic low frequency load shedding devices, grading the relays in their protective system, provision of high speed re-closing features on the circuit breakers and last but not the least a thorough inspection of transmission lines particularly before the monsoons are some of the devices which the authorities can use to ensure an uninterrupted supply of power. At any rate, the supply of power is an extraneous factor over which an undertaking has only a very limited control. There are, however, many internal impediments also like breakdowns due to mechanical and other reasons and delays in materials supply which cause considerable loss of production in fertiliser industry. As to the breakdowns the time is now, if ever, to give preventive maintenance its due place in overall functional structure by creating a separate preventive maintenance department. Regarding the delays in supply of essential raw materials, it must be said that till the country reaches a stage of self-sufficiency in basic raw materials, the procedures for their import must be streamlined to make them expeditious.

AGRICULTURE has been the main industry in our country for ages, but it is only about 25 years back that concrete steps were initiated for the development of fertilizer industry on sound footing. The first fertilizer factory was set up in the year 1947 at Ennore with a rated capacity of 10,000 tonnes of nitrogen per annum. The next large fertilizer factory which went into production in the year 1951 was set up at Sindri. The original capacity of this factory was 74,750 of nitrogen per annum. Since demand for the chemical fertilizer was growing fast, few more factories with moderate capacity like Nangal, Trombay, 2nd and 3rd stage expansion of FACT, Alwaye, Sahu Chemicals, E.I.D. Parry and Rourkela etc. came under production till the mid-sixties. As the pace of expansion of fertilizer industry lagged behind the rate of its demand, the Government of India decided to put up many more projects with larger capacities after the mid-sixties.

Today, F.C.I. alone is having 5 running Units with total capacity of 3,85,330 tonnes of nitrogen per annum. All the five Units are being further expanded either through schemes like modernization or rationalization or through big Expansion Project. Apart from the above, FCI is executing 6 new projects, each having capacity between 1,52,000 to 2,25,000 tonnes of nitrogen per year. It may be thus observed that whereas chemical fertilizer production in our country began with a meagre capacity of 10,000 tonnes nitrogen per annum in 1947, the rise in a period of over two decades has been manifold. The total installed capacity of nitrogen stands at about 1.5 million tonnes per annum. Similarly, the production of complex fertilizer has multiplied several times.

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Though the installed capacity of the fertilizer plants got a tremendous boost, but the overall performance of the industry has not been satisfactory. If we go through the history of each project, it would be observed that the nature of difficulties or bottlenecks has been varying from project to project. In certain cases, even when the equipments were obtained from the same manufacturers, the performance differed from site to site. But, despite these peculiarities, there are areas of common interest which deserve due consideration. Some such items which have adversely affected the plant performance are briefly dealt below.

Power Supply

Experience has shown that one of the factors which has caused major bottleneck to the fertilizer production has been the frequent failure of power supply. It may be due to faulty system or may be due to mishap on the transmission line, but the fact stands that the loss of production due to power interruptions particularly during the first few years of operation has been considerable.

The frequent interruptions of power supply not only cause production limitations, but also create many other problems like :

(1) mechanical and thermal shocks to process equipment.

(2) Damage to refractory lining of the reactors and the furnaces.

(3) Leakages in the steam and the gas lines.

(4) Leakages from the gland and the mechanical seals of the pumps.

(5) Choking of the pipelines etc.

It is imperative to involve the authorities responsible for the supply in the initial stages of the project with a view to incorporate the necessary safeguards in the supply system. In certain cases where the source of supply is located at a far off distance and the chances of disturbances cannot be eliminated, it would be worthwhile having a generation capacity within the factory to the extent that critical equipment could be fed from the local source of power supply.

Also in the case of long distance supply system, it would be worthwhile having the transmission at high tension—say 132 or 220 KV. The power supply authorities should also ensure to provide automatic low frequency load shedding devices, grade the relays in their protective system so that the faults are cleared within 0.1 second, also provide high-speed re-closing features on the circuit breakers. Before the monsoons set in, it is essential to arrange a thorough inspection of the transmission lines.

Association of Operating and Maintenance Personnel at the Design Stage

It is absolutely necessary to associate the personnel who are ultimately going to operate and maintain the plants, at the stage the project is being conceived. It would not be practically possible for the designer to anticipate the working problems without the help of those people who have been in the trade of maintenance and operation for the last many years. If the equipments are installed in the manner that they cannot be easily approached and attended at the time of breakdown or if the operating controls are located in inaccessible or congested area, the duration of downtime on them is bound to be prolonged. Involvement of maintenance personnel at the design stage itself is bound to bring down such eventualities to the minimum.

Training of the Staff

In order to operate and maintain the sophisticated fertilizer plants, it is essential to have a well-trained team of Operators and maintenance technicians. It is the responsibility of the Operator to ensure the normal operating conditions and take prompt action, should any abnormalities arise. Similarly, when a breakdown happens—take the case of a carbamate pump in the Urea Plant—it would be the job of maintenance technician to dismantle the assemblies like gland housing, plunger, cylinder head, cross head, bearing and crank shaft etc. In order to do this job precisely and correctly, we must have men having high level of skill. If the organization possesses qualified engineers alone, it would be difficult to meet the practical needs of the day today problems. Since acquiring requisite skill—whether it is maintenance problem or operational problem—one needs some experience, it is advisable to plan the training programme in manner that the maintenance crew completes the training well in advance of the erection activities at site and the operating crew before the trial runs of the plants are started.

Selection of Process and Materials

Fertilizer Plants are capital-intensive plants. As such, it would be prudent to select proven processes as also to make use of such materials to the maximum extent which are available from indigenous resources. Even if it means minor adjustment or modification at the design stage for accommodating what is indigenously available, it would be worth doing so or we would have to face a constant drain and strain on the limited resources of our foreign exchange.

Utilities

For any large size fertilizer factory, cooling water, boiler feed water and steam at various pressures are some of the basic requirements. Source of raw water may be from a nearby river or some lake or from tube well. The raw water would have to be treated accordingly for making it suitable for the services for which it has to be ultimately used.

Apart from the normal pre-commissioning precautions like introducing temporary strainers, flushing and cleaning the pipelines and checking the moving machinery for any excessive vibrations or any other abnormalities, it is extremely important to ensure the specified limits of purity of water before the same is fed to the system. It has happened sometimes that in our anxiety to push forward the commissioning schedule, the importance of this factor was not given due cognizance, resulting in choking of the heat-exchanger tubes, frequent failure on the waste-heat recovery system etc. In some of the plants, loss of production rose to thousands of tonnes of nitrogen per year on this factor alone. In fact, the unsteady conditions persisted till the affected equipments were either thoroughly repaired or completely replaced.

Waste Heat Boilers

Waste Heat Boilers form an integral part of fertilizer industry. As per the Indian Boilers Act, like any other fired Boiler, they have to be offered for inspection every year. Sometimes, it is possible to coordinate the job with the overall shutdown of the stream, but at times, the inspection may fall due outside the shutdown schedule. This results into an additional stoppage of the stream, causing considerable set-back to production targets. Though in the heavy chemical industry, there are number of equipments where the working conditions are far stringent than the waste heat boiler, but since the latter is covered under Indian Boiler Regulation and, therefore, the repairs and inspection procedures are more cumbersome and time-consuming, the loss of production occurring due to this factor is considerably higher than the former.

Keeping in view the above as also the practices prevalent in the advanced countries, the Central Boiler Board has recently agreed to extend the periodicity of inspection to 24 months instead of 12 months for Waste Heat Boilers, in the fertilizer factories subject to the conditions that the Chief Inspector of Boilers of the States is satisfied with the maintenance standard and the quality of boiler feed water.

In some of the ammonia plants, the Waste Heat Boiler in the synthesis section forms an integral part of the converter basket. Under the normal working conditions, the synthesis catalyst would need replacement after about 4-5 years. We can imagine the fate of the plant, having a capacity of 600 T/D and more if it has to be stopped for a period of around one month every year, so as to meet the stipulations under IBR. Even the extension of inspection periodicity to 24 months does not adequately help. In order to overcome this difficulty, the only way out is to treat the Waste Heat Boilers in the process industry at par with other equipments and amend the laws accordingly.

Leakages

Another factor which causes serious limitations on production as well as is responsible for frequent stoppages is the sudden development of leakages from the joints on pipelines and pressure vessels. It is true that it does not need high level of skill for making leak-tight joints, but unless the problem is tackled with due care, its frequency of recurrence cannot be brought under control. Since the working pressures are generally high and the conditions corrosive, if the joints are not thoroughly cleaned, polished and matched and proper care exercised while selecting the materials for jointing and packings, it is difficult to arrest this nuisance with success. The leaky joints not only make the plant dirty and unsafe, but at the same time, have an adverse effect on the efficiency of the plant—hence the necessity to give the due care.

Import Substitution

As stated earlier every effort has to be made to use indigenously available materials, but, at the same time, we cannot, at least for some years, be cent per cent free from foreign dependence. Some of the raw materials and spare parts have to be imported. The existing procedure for arranging the DGTD clearance, import licence and establishing the letter of credit are so cumbersome and time-consuming that each factory tends to overstock the items and thus inflate the inventory.

Preventive Maintenance

Though fertilizer industry is basically a chemical industry, in order to ensure its smooth and continuous operation, the sooner the part to be played by the maintenance department is recognized, the better it is. Whereas, utmost vigilance is called for from the operatives, it is at the same time binding on the maintenance team to evolve a system of maintenance that the plant outages are reduced to minimum. Keeping this end in view, the following steps need attention.

Daily Inspections

Every breakdown generally gives advance

warning. The question is how to listen to it and take prior or timely action. In order to keep the breakdowns under control, it would be necessary to prepare a comprehensive "check list" of all the equipment and depute a person to make the detailed inspection every day accordingly. Majority of the defects, revealed through these inspections, may be of minor nature and can be attended without arranging the stream shutdown. But if they go unnoticed, they would ultimately result in serious breakdown, involving considerable loss of productions. Some of the abnormalities may be such as cannot be attended to immediately. But once they have been brought to surface, preparatory steps can be initiated with a view to minimise the downtime.

Daily Planning and Daily Review

The plant incharges must develop a system of daily planning and daily performance review. Job priorities and its allocation should be decided in advance and then compared with the targets at the close of the day. This would help preparing realistic schedules and also better utilisation of the resources, as available.

Breakdown Analysis

Despite rigorous daily inspection, breakdown in a big chemical complex cannot be completely eliminated. These breakdowns may be classified as uncontrollable and controllable. It is the latter type which need further analysis, say department-wise, equipment-wise or nature of failure-wise etc. This should be recorded in a tabular form, date-wise, so that the repetitive failure and their frequency can be established. Unless, in a big complex, the weak spots can be segregated, it would not be possible to get at the root and find solutions.

Periodical Inspection and Overhauls

Each equipment needs periodical inspection and overhauls. Not only these activities must be dovetailed in the overall plan in the manner that the plant outage is minimum, but also with a view to determine the rational periodicity of inspection, the observations at each overhauls or inspection must be recorded in precise details.

Team Spirit

Operation and maintenance personnel are like the two wheels of the cart. Howsoever good may be the system of inspection and maintenance, unless there is good rapport between the two major partners, smooth running of the plant is not possible. Absence of the understanding would not only tend to increase the downtime, but would also make the task of analysis of failures extremely difficult. □

"If a key exists which will unlock the mysteries of human behaviour in organizations, it will be in the form of a theory of system."

—William G Scott

Metal Inspection in Fertiliser Plant Maintenance

S.R. Ramchandran*

Hydrogen blistering, stress-corrosion cracking, fatigue cracking and erosion are some of the most common examples of deterioration in plant and equipment in the fertiliser industry. With the advancement of technology, various sophisticated methods of inspection have been developed to detect these hazards in order to facilitate the timely action to counter them. Some of these methods consist of radiography, magnetic particle examinations, dye-penetrant examinations, ultrasonic examinations and the use of borescope and electromagnetic testors in inspection. While the use of these modern methods of inspection is necessary in proper maintenance of plant, machines and equipments, their effectiveness, however, to a great extent, would depend on a carefully worked out 'inspection system' implying thereby a clear framework of schedules, records of inspections, records of operating history, inspection procedures for each unit or section and a regular means of review with operating and maintenance personnel.

IT is an essential function of maintenance to keep plant and equipment safe for operation and protect against losses caused by failure and shutdowns. In modern Fertiliser Plants using large high capacity costly units, designed for operating continuously over long periods of time, the need for ensuring continuity of operation is all the more important. A failure of a part may result in the shutdown of the whole plant and cause considerable economic loss, both in loss of production and costly repairs and replacements.

Plant and equipment used in fertilizer manufacture operate under severe service conditions, which may cause deterioration of the materials of construction with the lapse of time. Even with the use of equipment of the best design and construction, it is impossible to prevent deterioration. To ensure continuity of operation and protect against failures and shutdowns, therefore, it is necessary to have systematic organised inspection under the supervision of qualified engineers. Such systematic, organised inspection helps to anticipate and plan requirements in advance of shutdown and can play a key role in protection against losses caused by damage to plant and personnel.

From years of past experience, especially in the Petroleum Industry, a considerable body of knowledge is now available concerning causes of deterioration of metals and failures. The

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progress made over the last 25 years in inspection techonology, particularly in non-destructive testing (NDT), provides reliable scientific methods of inspection to detect evidence of deterioration or damage to metals well in advance of the failure stage.

CONDITIONS CAUSING DETERIORATION OF METALS

Since the primary purpose of inspection is to ensure availability of equipment to operate safely at its specified design performance, it is of utmost importance to recognise and understand the conditions causing deterioration and failure. Under normal operating conditions, deterioration is usually but not always gradual. It may be in the form of metal loss (thinning) or structural or chemical damage resulting in weakening of the metal (cracking, embrittlement, decarburisation etc.) Abnormal operating conditions, arising from instrument failure or fire etc., may cause much more rapid deterioration and damage. There is a large diversity of operating conditions which cause various kinds and degrees of deterioration of metals. The following summarises the most common and the most serious types of deterioration and their causes.

General Corrosion and Erosion: Many of the fluids handled—acids, salt solutions etc.—in a Fertilizer Plant react with metals of construction, resulting in a gradual loss of weight (thinning) which is called corrosion. Thinning also is caused by high velocity flow of liquids. This is called erosion. In some services, where both corrosion and erosion occur, the metal loss can be far more rapid than that arising from the separate effects of corrosion and erosion. Corrosion rates (rate of metal loss with time) are not always constant, but are dependent on such variables as concentrations, temperatures, flow rates etc. The inspector must, therefore, be able to assess anticipated life and frequency of inspection required.

Stress Corrosion Cracking: This is caused by the combined effects of corrosion and tensile stress. Where this occurs, neither corrosion alone in the absence of stress nor stresses present in the absence of corrosion would have produced cracking. Stress-corrosion cracking occurs in a particular alloy only in specific environments. For example, carbon steel is susceptible to stress-corrosion cracking in hot nitrate, hot carbonate waters and sulphonitric acids; austenitic stainless steels in hot chlorides (especially in the presence of oxygen), copper alloys in ammonia. In most cases, the internal or residual stress associated with fabrication operations such as forming, bending, press or shrink fitting, welding and heat-treatment are chiefly responsible for cracking. Hence, the areas prone to stress-corrosion cracking are cold worked areas, areas adjacent to welds or points of stress concentration.

Caustic Embrittlement: This is a specific form of stress-corrosion—cracking of carbon steel under stress and in contact with caustic solution.

Intergranular Corrosion: This is a specific form of corrosive attack on austenitic stainless steels, localised at particular areas which have been sensitised during forming and fabrication—e.g. areas adjacent to weld seams. During heating in the range of approximately 450°C-800°C, unstabilised austenitic stainless steels are subject to a structural change, viz., the precipitation of chromium carbide at the grain boundaries. In this condition, the steel is said to be sensitised and is susceptible to preferential corrosive attack at the grain boundaries without general corrosion or thinning. In course of time the intergranular attack may penetrate through the entire thickness, causing rupture and leaks. Since this attack is localised at sensitised areas adjacent to welds in process vessels and equipment, suitable inspection can reveal progress of attack before actual failure takes place.

Blistering : This is another type of corrosion attack which occurs both in alkaline solutions and in acid solutions when steel is slowly corroded by weak acids. Blistering is often associated with hydrogen sulphide. Some of the atomic H formed as a product of the corrosion reaction diffuses into the metal. When this hydrogen encounters voids, laminations or non-metallic inclusions in the metal, molecular hydrogen is formed which cannot diffuse through the steel. Therefore, it accumulates in the void, building up pressure and eventually causes the steel to blister or rupture. The blisters have a characteristic appearance in the form of bulges over circular spots often with the presence of cracks on the surface at the middle.

Damage due to High Temperatures : (1) Metals and alloys subject to high service temperatures are susceptible to structural changes like graphitisation, decarburisation, embrittlement etc. which may cause serious deterioration in physical properties like strength and ductility and lead to failure. The nature of damage occuring depends on the service environment. Specifically, the various environments of interest in fertilizer plants are : steam, ammonia, sulphurous gases and hydrogen atmospheres.

Steam : In steam service, carbon steels and carbon molybdenum steels are subject to oxidation and decarburisation at temperatures over about 450°C. Low-alloy Cr. Mo. steels are resistant to this damage up to a temperature of 550 C. Higher Chromium Steels and stainless austenitic steels are resistant even at higher temperatures up to about 900°C.

Ammonia : In ammonia environments ordinary austenitic stainless steels are subject to severe damage by nitriding at temperatures around 550°C. The damage is due to the dissociation of ammonia and the formation of nascent Nitrogen which reacts with the Chromium/Iron to form nitrides. This kind of attack leads, in course of time, to complete disintegration of the metal. Alloys with higher Nickel (over 30%) provide resistance to this type of attack.

Hydrogen Atmosphere : Hydrogen attack of metals and alloys is a function of hydrogen, partial pressure and temperature. At high temperatures, the carbon in the steel reacts with hydrogen, forming methane (CH_4) and causes micro-cracks or fissures in the steel surface which penetrate deeper into the thickness in course of time. The operating limits for various steels have been well established by the Nelson curves. (see Fig. 1)

There are other damaging effects of high temperature independent of the environment. These are creep-cracking and precipitation embrittlement. Creep-cracks form in stressed parts exposed to high temperatures. Normally, such parts are designed for a definite life at the design operating temperature. But, overheating even infrequently and for short durations may drastically reduce life, because the damage is cumulative. Creep-cracks in the incipient stages can be readily detected by radiography or by metallographic examination.

Precipitation embrittlement occurs in certain alloys at particular temperatures. For example the 17% Cr or higher Cr steels are severely embrittled on exposure to a temperature of around 500°C. The embrittlement is due to the precipitation of a Chromium-rich carbide phase and severely reduces ductility of the steel so that in the cold state it can be broken easily by a small impact.

Fatigue Cracks : Fatigue cracks are caused generally in machinery parts like shafts, studs etc. as a result of alternating stresses in service. Less frequently, cracking may occur in piping or vessels as a result of thermal fatigue. that is, cycle of temperature changes. Such cracks start at the surface and propagate over a period of time, at first slowly and then rapidly. Periodic inspection of vulnerable parts can establish such cracks before complete failure occurs.

Some Common Examples of Deterioration in Service

The following are some examples of deterioration and failure of metal in service.

Hydrogen Blistering: In the CO_2 Water Scrubbers of an Ammonia Plant, corrosion blisters were observed on the inside of the Carbon Steel Shell after 15 years in service. The general corrosion and thinning rate was low. This was a typical case of hydrogen-blistering occurring as a result of corrosion by weak carbonic acid. These blisters were detectable by ultrasonic examination from the outside surface.

Stress-Corrosion Cracking: In the waste-heat boilers of an Ammonia Converter, the austenitic S.S.Tubes were cracking near the gas inlet (hot) end. This was a typical case of stress-corrosion cracking in the presence of hot chloride in the medium (boiler feed water). Though the level of chlorides was low there were conditions of alternate wetting and drying at localised areas, resulting in increase in concentration of corrodent. Cracks in tubes like the above are detectable by borescope examination or by eddy-current probes.

In the Decomposed Liquor storage tank of an Ammonium Sulphate plant, extensive cracking was observed in the S.S. Shell Plates in the top courses only. There was no such damage in the lower courses. This was a typical case of stress corrosion cracking of austenitic stainless steel as a result of alternate drying and wetting of the surface leading to concentration of corrodents in the area above the liquid level. Vapour space corrosion in atmospheric storage tanks had also been found to occur because of hydrogen sulphide in the presence of moisture and oxygen. This type of corrosion is confined to the vapour space, where condensation of moisture can occur.

Fatigue Cracking: The piston rod of a synthesis gas compressor in an Ammonia Plant fractured at the screwed end at the X-head connection. Investigations revealed that it was a cause of fatigue failure, starting from a crack at the root of the threads.

Another example of fatigue failure was that of coupling bolts between X-head and C-rod of a syn-gas recirculator in an Ammonia Plant. Fatigue failures like the above occur at locations of stress concentrations, like changes in X-section, roots of threads, adjacent to weld-repairs etc. Since the fatigue cracks propagate over a period of time prior to failure, it is good practice to periodically examine machinery parts like the above which are subjected to fatigue loading, by dye-penetrant or magnetic particle examination for the presence of cracks.

Erosion: The inlet header to the ammonia condenser in an ammonia plant sprang a leak at the tee-joint. On examination, it was revealed that the area at inlet had thinned down excessively as a result of erosion. This dangerous condition is now detected by radiography of the area or by ultrasonic examination while in service. Areas susceptible to such thinning due to erosion are those where there is impingement of fluid, or sudden change in direction as at sharp bends or elbows in lines. The presence of even moderate corrodents in the medium accelerates the loss of metal.

Creep-Cracks: The reformer tubes of 25Cr-20Ni stainless steel in a Methanol Reactor developed a number of cracks in service. When weld repair of the cracks was attempted, new cracks formed adjacent to the old cracks or extending from the previous cracks. This was a typical example of creep-cracks occuring as a result of service at high temperatures over a period of time. Radiographic examination showed numerous internal cracks not visible on the outside.

These cracks occur in heater tubes or reformer tubes because of local overheating arising from catalyst breakdown or flame impingement. Generally repair of such cracks is futile. It is recommended to identify the defective portion and cut out the piece of tube containing cracks and butt-weld a new piece.

Methods of Inspection and their Application

In choosing the method of inspection required, it is important to recognise the object of the inspection and the nature of flaws or defects to be checked. Visual examination and a knowledge of the service conditions and previous history will help in establishing the extent and nature of inspection required. In almost all cases, visual examination either by naked eye or with the help of a magnifying glass is an essential first step, which cannot be overrated. Visual examination can tell whether :

a) additional cleaning is necessary for more careful inspection ;
b) severe cracking or other surface defects are present and if so their location ;
c) additional methods of inspection may be used for more complete inspection;

The common methods of inspection and their fields of application are summarised below : (See Annexure III—Guidelines for NDT Methods).

Borescope : This instrument is an aid to visual inspection of interior surfaces of deep holes, exchanger tubes, the root pass of inaccessible welds, etc. The instrument is inserted into the hole or tube and after switching on the light can be rotated 360° to scan the entire surface through the eyepiece.

Radiography : In this method, the metal to be inspected is placed between a source of X-rays or r-rays and a photographic film. Due to differences in the absorption of rays by cracks, voids, non-metallic inclusion etc., compared to solid homogenous metal, the flaws are indicated in the developed film as darkened areas against the lighter appearance of the adjacent sound metal. Absence of flaws and uniformity of thickness will produce pictures (radiographs) of uniform shade. Though radiography is mostly used for inspection of newly constructed equipment-welds, castings, forgings etc., it can also be used in service inspection of operating equipment to detect cracks, excessive thinning or other serious internal flaws. Portable equipment is available for field inspection.

Magnetic Particle Examination : This method utilises a means of magnetising the area to be inspected and a magnetic powder such as fine iron filings. Defects on the surface or near the surface cause a distortion in the magnetic field and the particles arrange themselves in a pattern outlining the discontinuity or flaw, thereby indicating the location, extent and nature of flaw. The equipment consists of a generator, much like a welding machine producing constant high amperage current. Two cables with prod contacts at the ends are used to contact the work to be inspected, inducing a magnetic field in and around the area. There is some arcing at the contacts which may mar a machined surface. In such cases, other means of magnetisation are used, like wrapping coils of cable or using permanent magnets.

This method can be used only on magnetic materials and is chiefly used for detection of surface cracks in welds, castings, forgings or heat-treated parts, shafts etc. The type of defect is indicated by the pattern of the magnetic powder. Surface cracks show up as a fine line along the crack. Sub-surface cracks show up as a broader line of accumulated powder. Porosity is indicated by scattered piles of powder over the defects.

Dye-Penetrant Examination : This is also a non-destructive method of locating surface flaws in metals, such as cracks, pores and laps which are open to the surface. The method consists of applying a red penetrant dye to a clean area, removal of penetrant which has not entered flaws and spraying on a white developer which brings out the entrapped penetrant showing up as red indications on the white background. The characteristic of the red marks such as the rapidity with which they develop and final size and shape are excellent clues as to the nature of the flaws. The rate of bleeding is an indication of the width and depth of the defect, while the extent of bleeding is an indication of the volume of defect.

A variation of the above is the fluorescent method, which makes use of a fluorescent penetrant, which glows under a high intensity ultra-voilet light. This method is more sensitive than the visible penetrant method and very fine surface imperfections will be defined by the glowing fluorescent penetrant.

Apart from detecting surface-flaws, the penetrant method may be used to detect leaks in vessels or tanks. These methods are suitable for detecting cracks due to corrosion, fatigue etc.

Ultrasonic Examination : Ultrasonic instruments are of two types—the resonance type and the pulse-echo type. In the resonance type, the instrument consists of an electronic oscillator which transmits an electric energy of constant ultrasonic frequency to a crystal (transducer), which converts this energy into mechanical pressure waves which travel through the thickness of the material examined at a constant velocity. The pressure waves are reflected back from the opposite surface. Since the velocity is constant, the time taken for a wave to traverse the thickness and back is a function of the thickness to be determined. If frequency of oscillation is adjusted to a value at which a wave is propagated from the transducer at exactly the same instant that the previously reflected wave has arrived back, resonance occurs and the time interval between recurrent cycles is directly proportional to the thickness. The resonant condition is detected by the instrument by virtue of the increased power required to drive the oscillator.

In the pulse-echo type instrument electric pulses are generated instead of continuous waves as in the resonance type. The electric pulses are transformed into ultrasonic waves, which are beamed into the material by means of piezoelectric transducer. These ultrasonic waves travel through the material under inspection and are reflected from the back surface (back echo) or from any internal discontinuity or flaw (defect echo). These "echoes" are indicated on a cathode-ray-tube (CRT) screen. The interval between the initial pulse and the back reflection on the CRT screen is proportional to the thickness of the part examined. Internal defects like laminations and inclusions are indicated either by loss of back reflection or the appearance of defect echoes on the screen. Longitudinal wave (straight-beam) inspection is used for detecting laminar discontinuities i.e. discontinuity parallel to the surface, while shear-wave (angle-beam) inspection is used for detection of transverse defects like cracks. By moving the probe or search unit over the surface, the entire volume of material can be probed for defects or flaws or for determination of thickness.

Electromagnetic Testers : These instruments can locate flaws by detecting changes in electrical or magnetic characteristics of the metal. They are of two types:—magnetoinductive and eddy-current. By comparison with a known standard, variations in dimensions, composition, structure and defects can be determined. A very useful application of the eddy-current instrument is in the inspection of non-magnetic exchanger tubes for defects and thinning. As the electro-magnetic pick up (probe) is moved through a tube, the variations in the tube-wall are indicated on an electronic recorder and recorded on a strip chart. As the probe passes through a tube, the recording pen oscillates across the centre-line of the moving chart. This oscillation results from changes in quality and thickness of tube wall surrounding the probe as it moves. The chart centre line is taken as the reference for normal tubing and any deflection of the trace to either side indicates a deviation from normal.

Other Field Tests : In addition to the above methods of non-destructive testing and inspection, there are other methods available in the field to determine deterioration in properties, structure etc. of metals and alloys.An important and useful method is metallography. Portable equipment and methods are now available for carrying out such examination on equipment *in situ*, where there is adequate access to the part. Selected spots on the surface are polished and etched and photomicrographs taken with a Polaroid camera, which gives instant pictures, without the need for any laboratory or dark-room facilities. (This equipment—the spot-polisher and microscope with camera—is available with the FCI Ltd. P & D Division, Sindri and has been successfully used in many field investigations),

In addition, the writer is familiar with another field method for metallographic examination, called the "SUMP TEST". This is a method developed in Japan. The test is essentially meant to examine presence of precipitates (like Cr 23 C3 in austenitic S.S.), microcracks and check general soundness of microstructure. The method uses a replica, which is examined under a metallographic microscope. The replica is obtained on a SUMP plate (similar to transparent celluloid) by sticking it by a SUMP solution onto a polished and etched spot to be examined. The plate is peeled off gently and stuck on a card to lay it flat and provides a permanent record.

ORGANISATION AND SYSTEMS FOR INSPECTION

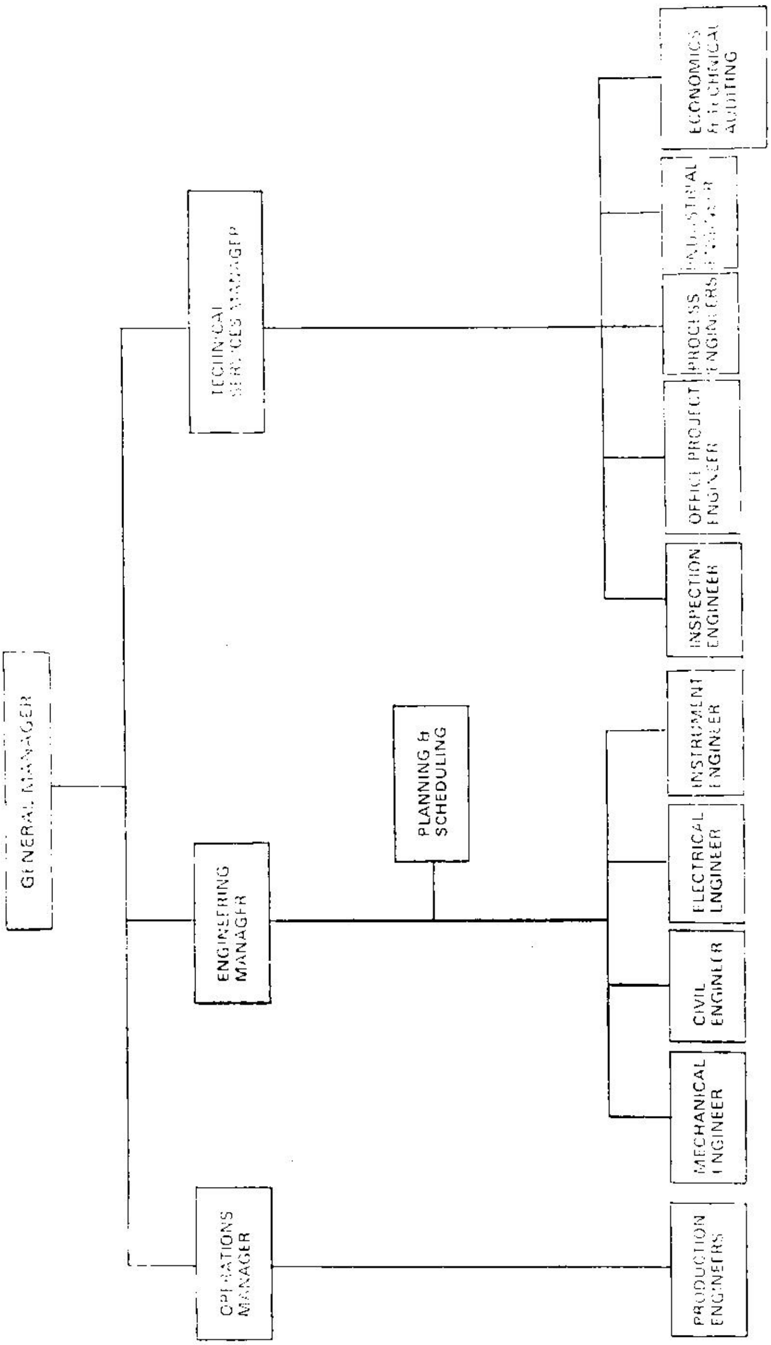
The key to success and effectiveness of any activity is ORGANISATION, and Plant maintenance is no exception. In fact, in modern plants the technological demands on maintence to ensure reliability of equipment are high. Maintenance is no longer a matter for traditional craftsman, but calls for a variety of engineering skills and knowledge—in other words, it is no longer craft or practice-oriented, but techonology or knowledge-oriented. It is important to realise that this represents a basic conceptual change and not just a shift in accent or emphasis. Organisation as discussed here refers to the framework of people and positions and their functions and responsibilities. By now, we know that the actual doing of a task and the planning and analysis preceding the determination of what, when and how of the task calls for different skills, aptitudes and abilities and are not done well by the same person or people. In maintenance, for instance, the actual performance of the maintenance task and its supervision call for skills in crafts without a high level of knowledge, skill in human relations—i.e. motivating and getting the best out of people; on the other hand, planning of preventive maintenance and inspection requires a higher degree of specialised knowledge, skills in engineering analysis and techniques, meticulous attention to details.

In fact, the latter constitute the Staff services, to the line function of maintenance. Two examples of organisation for a Petroleum Refinery and a Fertilizer Plant are shown in Annexures I and II respectively.

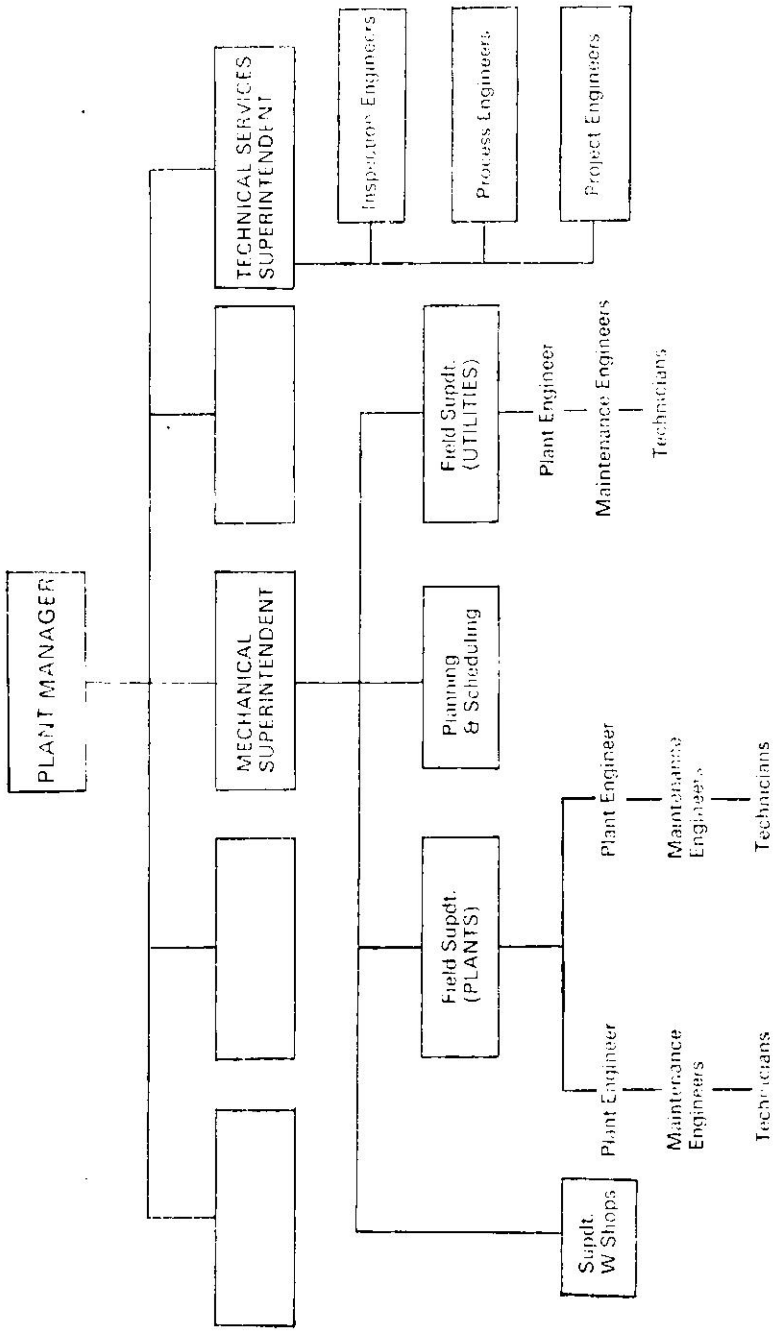
The system : Even the best trained and skilled men can be ineffective unless the system of working is carefully worked out to achieve the best results. The "System" means a clear framework of schedules, records of inspections, records of operating history, inspection procedures for each unit or section, and a regular means of review with operating and maintenance personnel. It is only through such a "system" that the skill and efforts deployed for inspection can be most effectively used to attain its prime objective, viz., to ensure continuity of operation and protect against losses and damage to plant and personnel caused by failure and breakdowns. □

The benefits derived by implementing preventive maintenance programmes will depend largely on the geographical location of the plant, the process, the method of manufacture, the products produced, the cleanliness of the plant and surroundings, the effectiveness of the preventive maintenance programmes and the intensity with which it is carried out, and lastly, the fervour of the persons carrying out the programmes.

—Machine Building Industry



ANNEXURE I Organisation Outline of a Refinery



ANNEXURE II—Organisation for Maintenance in a Modern Fertiliser Plant

Annexure III

GUIDELINES FOR NONDESTRUCTIVE TESTING METHODS

Inspection Method	*When to Use*	*Where to Use*	*Advantages*	*Limitations*
Eddy current	Measuring variations in wall thickness of thin metals or coatings ; detecting longitudinal seams of cracks in tubing ; determining heat treatments and metal compositions for sorting	Tubing and bar stock, parts of uniform geometry flat stock, or sheets and wire	High speed, non-contact, automatic	False indications result from many variables ; only good for conductive materials ; limited depth of penetration
Radiography: X-rays	Detecting internal flaws and defects ; finding welding flaws, cracks, seams, porosity, holes, inclusions, lack of fusion ; measuring variation in thickness.	Assemblies of electronic parts, castings, welded vessels ; field testing of welds ; corrosion of non-metallic material	Provides permanent record on film ; works well on thin sections ; high sensitivity ; fluoroscopy techniques available ; adjustable energy level.	High initial cost ; power source required; radiation hazard ; trained techniques needed.
Gamma rays	Detecting internal flaws, cracks, seams, holes, inclusions, weld defects; measuring thickness variations.	Forgings, castings, tubing, welded vessels ; field testing welded pipe, corrosion surveys.	Detects variety of flaws; provides a permanent record ; portable; low initial cost ; source is small (good for inside shots) ; makes panoramic exposures	One energy level per source; radiation hazard ; trained technicians needed ; source loses strength continuously.
Magnetic particle	Detecting surface or shallow sub-surface flaws, cracks, porosity, non-metallic inclusions, and weld cracks.	Only for ferromagnetic material parts of any size, shape, composition, or heat treatment.	Economical, simple in principle, easy to perform ; portable (for field testing) : fast for production testing	Material must be magnetic ; demagnetising after testing is required; power source needed ; parts must be cleaned before finishing.
Penetrant	Locating surface cracks, porosity, laps, cold shuts, lack of weld bond, fatigue, and grinding cracks.	All metals, glass and ceramics, castings, forgings, machined parts, and cutting tools ; field inspections.	Simple to apply, portable, fast, low in cost ; results easy to interpret; no elaborate setup required.	Limited to surface defects ; surfaces must be clean
Ultrasonic	Finding internal defects, cracks, lack of bond, laminations, inclusions, porosity ; determining grain structure and thicknesses.	All metals and hard nonmetallic materials ; sheets, tubing, rods, forgings, castings; field and production testing ; in-service part testing ; brazed and adhesive-bonded joints.	Fast, dependable, easy to operate; lends itself to automation ; results of test immediately known ; relatively portable, highly accurate, sensitive	Requires contact or immersion of part ; Interpretation of readings requires training.
Resonance	Gauging thickness and locating laminar flaws			

Source : *Metal Progress Data Sheet, August 1968*

Technical Aspects of Industrial Safety

K. Kumar*

The old adage that 'prevention is better than cure' still holds good so far as industrial safety, particularly in chemical process industries, is concerned. If factors like climatic conditions, characteristics of raw materials, plant layout etc are taken into consideration at the very stage of designing a plant, much of the dangers to industrial safety could be nipped in the bud. This does not, however, discount the need for proper vigilance at the operational stage to spot out hazards and take corrective action, but such vigilance must be regarded as supplement rather than substitute to proper designing and layout of the plant.

THE importance of safety of plant and equipment and plant-operators in chemical process industries cannot be over-emphasised. Chemical plants are normally very capital-intensive and handle sophisticated, hazardous and dangerous chemicals which present never-ending and varied problems for plant design and operations. It is estimated that almost a new chemical is developed every half-an-hour and full information regarding its behaviour in storage, handling and processing, and its effect on persons handling it, cannot be fully evaluated and incorporated in the plant design and thus there is need to provide safeguards for probable eventualities.

Based on experience of many chemical industries as well as designers of chemical plants, the following is an attempt on listing some of the aspects and considerations which will help to improve safety in plants.

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Determine and Design for Expected Range of Climatic Conditions:

(*a*) *Ambient Temperature* : Check db and wb temperatures including mean normal, minimum and maximum, as well as data on percentage of time occurring; or time not exceeded and hours occurring. This criteria guides in assessing requirements of winterising, heat tracing and heat insulation, rain protection, etc., and should be taken into account for determining swings in utilities load to compensate for heat losses or gain in process equipment and piping, design of air-coolers and cooling tower systems, etc.

(*b*) *Wind-rose* : Data showing the yearly percentage of wind direction and intensity as well as seasonal variations helps to determine layout of fired equipment in relation to areas handling flammable materials, layout of equipment discharging vapours, hot gases e.g., cooling towers, air-coolers, vents and stacks and their heights.

(*c*) *Earthquake and Storm* data including history of electrical storms guides to plan the requirements for emergency or standby services for power, instrument air, cooling water, steam, fuel or inert gas; safety for the electrical system like earthing of stacks, tank-farm and tall equipment, electrical relays and interlocks for momentary and extended electrical outages, design wind loads and earthquake bracing on structures, building and equipment, foundation levels of critical equipment over flood or hurricane levels.

(*d*) *Rainfall* data including maximum hourly intensity as well as mean, maximum, normal hourly and monthly rainfall guides the effective layout of storm water drainage, waste treatment facilities and effect of sudden temperature changes on hot uninsulated equipment, space heaters and electrical motors.

Characteristics of Materials

This comprises raw materials, intermediate and final products, their behaviour in storage and processing, flammability, flash point, auto-ignition temperature, explosive range, spontaneous heating, dielectric constant, shock sensitivity, pyrophorosity, toxicity and corrosive ness, stability, fouling, formation of precipitates and polymers, etc.

Depending upon the characteristrics of the chemical being handled, the design of the equipment should be made to cater for any of the eventualities which have a direct bearing on the properties of the chemical, e.g , if the chemical is corrosive in nature, the material of construction of equipment coming in contact with it must be chosen in regard to its suitability. Pressure relieving devices should be provided in case there is a chance of a pressure build-up due to failure of agitation, instrument failure, temperature rise or utilities failure and so on.

Process Reactions :

Provision has to be made for deviations in process conditions for :

— temperature and pressure conditions,
— instrument failure,
— agitation failure,
— failure of utilities,
— ingress of air into the the process system (in vacuum service)
— leakage of inflammable material
— malfunctions of safety equipment, valves, etc.

Therefore, the suggested guidelines for safety considerations are :

— Know and learn the process in detail.
— Assemble reliable data on the pysical, chemical and hazardous properties of all materials involved.

(Suggested publications are : Manufacturing Chemists Association (MCA), National Board of Fire Underwriter (NBFU), Manufacturers' literature—most of the manufacturers furnish detailed handling and properties literature for chemicals manufactured by them.)

— Determine and follow recommended practices for handling hazardous materials.
— Determine how the plant is to be manned and operated. It is essential to know

the background of personnel who will have to operate the plants to draw up operating instructions, safety training programmes, emergency shutdown procedures, etc. It is a well known fact that workers who are drawn from rural or agricultural background are not safer than those of industrial experience and technical background. This aspect cannot be overlooked in India as the emphasis is on shifting industries to so-called backward or underdeveloped regions in the country.

— Determine and use applicable Codes[1], Standards[2], or Recommendations[3].

With the growth of chemicals industry and experience gained by it, considerable useful and valuable literature has been compiled and expertise developed and published in the form of Codes for design and Practice and Standards. A list of relevant sources of Codes and Standards may be as under. The literature cited is of American origin. Corresponding literature published is available from almost all the leading industrial countries :

API — American Petroleum Institute.

ASME — American Society of Mechanical Engineers.

TEMA — Tubular Exchanger Manufacturers, Association.

ASA — American Standards Association.

NFPA — National Fire Protection Association.

OSHA — Occupational Safety and Health Act.

ANSI — American National Standards Institute.

ASTM — American Society of Testing Materials.

NEMA — National Electrical Manufacturers' Association.

— U.S. Bureau of Mines.

— Department of Transportation.

— National Bureau of Standards.

— Underwriter Laboratories Inc.

— Research Bulletins.

In India too, codes and standards are being compiled and published by Indian Standards Institute and other Govt. organisations, e. g., Factory Act, Explosives Effluent Board Regulations, etc.

Probably the best known and extensively referred publication by ASME is "ASME Boiler and Unfired Pressure Vessel Code" and its related vessel and piping design publications. Various sections under the above code are shown in Table I. on the next page.

Definitions :

1. *Code* : A document containing only mandatory provisions (using the word 'shall' to indicate requirements). Explanatory material may be included only in the form of fine prints note, foot-note or appendix.
2. *Standard* : A document containing both mandatory provisions (using the word 'shall' to indicate requirements), and advisory provisions (using the word 'should' to indicate recommendations).
3. *Recommended Practice:* A document containing only advisory provisions (using the word 'should' to indicate recommendations) in the body of the text.
4. *Manual* or *Guide*: A document which is informative in nature, but does not contain requirements and recommendations.

Table I

Section	Topic
I	Power Boilers
II	Materials Specifications, Parts A, B,C.
IV	Heating Boilers
VIII	Pressure Vessels, Div. I & II
IX	Welding qualifications
X	Fibre-Glass, Reinforced Plastic, Pressure Vessel Case Interpretation Book

ASMA Power Test Codes (P.T.C.)

PTC-4.3	Air Heaters
PTC-6	Steam Turbines
PTC-9	Displacement Compressors, Vacuum Pumps and Blowers
PTC-10	Compressors and Exhausters
PTC-14	Evaporating Equipment,

Specifying that an equipment should be 'in accordanee with appropriate and applicable code' does not necessarily assure safe piece of equipment or unit. It is essential that correct Codes and Standards are specified and proper follow-up given in respect of details as regards the specifications and correct methods or sound engineering practice. The standards and codes are not mandatory but represent minimum requirements that good engineering practice dictates. Some of the well-established industries likes SHELL, Union Carbide, ICI, and a host of others in Europe have developed their own standards and codes to facilitate uniformity and ensure safety based on their own plant and operating experience.

Lay-out of Plants and Operating Units

Due to limitation of space, sometimes the equipments in plants are laid out without due considerations of maintenance need for non-obstructed operating areas for plant operators or removal and movement of equipment in and out of the plant. The installation of pressure-relieving devices like safety valves and rupture discs should be planned so as to conduct the products of discharge safely into knock-out drums or flare system.

Storage facilities for raw material, intermediate products or finished products, if of inflammable nature, must be given due attention and provided in areas sufficiently away from process plants as well as vents and stacks which may emit hot gases. As far as practical, storage within a plant should be avoided or be kept at a minimum. Due care for segregating the area of storage in case of spills should be provided and built-in fire-fighting equipment provided to cater for such eventualities.

Document design considerations in the operating or equipment manuals highlighting the various hazards considered during design stage.

Electrical Equipment : The selection of electrical equipment including electronic instrumentation should be based on classification of process areas as per relevant API or other equivalent code to prevent hazards which may be caused by sparking in electrical equipment.

Ventilations and Pressurisation : Due consideration must be given to the ventilation aspect of Process areas to ensure that no pockets of light flammable or toxic gases are formed. Control Rooms should be safely away from plants and if they have to be located near to proeess areas, they should be pressurised with clean air drawn from safe areas. Similar consideration should also be given to locate the suction lines of air compressors.

Plant Trenches or Drainage Channels : To avoid hazards due to accumulation of heavier-than-air hydrocarbons which may be released in the plant due to any reason ; fire break baffles or seals must be provided in the trenches or drains in the plants.

The foregoing are essentially some of the technical considerations to be taken into account while designing or erecting a chemical plant. Safety aspects to be considered and kept in mind during the operation of a plant are essentially corrective or preventive. Some of these are listed as under :

(*a*) *Technical Training* : New employees must be indoctrinated to plant safety from the first day of their joining and should be made absolutely familiar to plant operations, nature of chemicals being handled in the plant, emergency procedures for catering to plant abnormalities etc. After indoctrination, a continuous training and education programme should be maintained for all levels of responsibilities.

(*b*) Devise suitable procedures to ensure that no maintenance work can be undertaken in a plant equipment without taking suitable steps to make the equipment safe to work upon. Before undertaking maintenance work, the equipment must be made gas-free and positively isolated from other equipment or pipelines to ensure that no hydrocarbon or toxic substances can find their way into the equipment being handed over for maintenance work. While gas-freeing, proper steps to safeguard the personnel from the release of hydrocarbon or hazardous chemicals must be ensured by using protective clothing, gas masks, etc. Equipment has been devised and are available to indicate gas freeing of vessels and pipelines and these should be used as a practice before entering any vessel for maintenance work.

To prevent any sparking due to static charge on non-conducting material, stastc charge indicators are also available to indicate the extent of charge on the equipment or even plant operators. The equipment should be used in areas where static charge may cause a spark in a hazardous location.

If the maintenance work is to be carried out on an equipment which has an electric, steam or air prime mover, it must be ensured that the prime mover is properly isolated from the energy source and there is no chance of accidently energising the prime mover.

(*c*) *Inspection of Equipment* : Practically all chemical plant equipment suffers deterioration as a result of operating conditions, the extent of deterioration being dependent upon severity of operating conditions. The primary function of inspection is to assure that equipment is safe to operate; that conditions causing deterioration and failure are recognised and understood. Periodic inspections establish metal loss rates, and such rates determine the frequency of inspection and predicting life of the equipment. Sometimes deterioration is not indicated as loss of metal but shows up as cracking or as difficulties in effecting welding repairs. In such cases metallurgical examination is indicated.

Factors causing deterioration and failure of the material of constuuction of equipment can be enumerated as under :

1. *Corrosion :* is the biggest single contributing factor and is caused by a host of variables, like chemical constituents of process material, pH, temperature, rate of flow, dissolved oxygen in process streams, etc.

2. *Erosion*: is the physical wearing away of metal by moving streams of liquids or gases specially when these carry solid particles. Erosion is particularly noticeable in areas where flow is restricted, or there is change in direction of flow, in areas of excessive turbulence etc.

3. *High Temperatures*: All metals and alloys undergo changes when heated above a certain temperature range, viz, structural changes and chemical changes. Due to these changes the physical properties of metals are affected and the design parameters which are taken at room temperatures do not hold good, and the materil can go under permanent deformation with time at stresses much below the apparent elastic limit. Similarly, properties of metals undergo a change under subnormal temperatures and metals are therefore prone to brittle fracture at low temperatures.

4. *Excessive Pressures* : Excessive pressures can be caused by :
   a) Added heat in excess of normal operation requirement
   b) Thermal expansion of trapped liquids
   c) Hydraulic Hammer
   d) Inadequate or defective vents on vessels or storage tanks
   e) Pulling of vacuum in vessels not designed for vacuum service
   f) Overloading of equipment or structures.

If the above factors are recognised, an inspection programme can be planned and enforced to look for the symptoms of failure and corrective action taken well in time. With the importance of keeping the plants on stream for maximum possible duration, a number of sophisticated and reliable instruments have been developed and are increasingly being used. Some of the specific tools to predict condition of equipment are :

Thickness testers, Leak Detectors, Crack Detectors, Ultrasonic, Gamma-ray, X-ray, Magnetic particle Inspection, Vibration Measuring Instruments, Infra-red Introscopes, Dye-penetrants, Fluorescent Penetrants, Electronic Tube Callipers—indicating and recording type.

These inspection tools help in identifying the symptoms and compiling the history of the equipment under observation. Analysis of the results of these observations gives the experienced engineer an insight to the probable life of the equipment and helps to take steps for preventing equipment failure and thereby a possible unsafe condition.

In addition to the above-mentioned inspection tools which are normally non-destructive tools, various other inspections have to be maintained on protective instruments or control loops, safety and pressure relief valves. It is advisable that regular periodic checks must be maintained and recorded on pressure controllers, flow controllers, temperature controllers to ensure that they are functioning as per requirements and if found erratic, the factor contributing for the error be rectified.

Sometimes the response of the controllers may not be immediate or may be sluggish due to malfunction of the controller and therefore various alarms and interlocks must be incorporated in the process system to convey audible and visible warning to the plant operator in the control room. These alarm equipment should also be checked periodically to ensure their proper function. The frequency of checks being determined by the conditions observed during the checks.

(*d*) In spite of all precautions being taken for ensuring the proper working of the plant, plant workers may still at times be exposed to conditions which require immediate correction and attention to the worker. Safety showers, eye fountains should be provided in plant areas where a worker may encounter a possible exposure. The approach to these showers or fountains should be clear and unobstructed at all times. Provision of First Aid Centre should be planned in plant lay-out.

(*e*) And lastly, as an insurance against plant damage due to fire, adequate and reliable fire fighting provisions should be incorporporated in the plant layout. Standby diesel engine-operated fire pumps are necessary to ensure adequate supply of water at proper pressure. The fire pump drive should automatically be energised in case the water pressure falls to a predetermined value, which is ascertained by the operating pressure of fire fighting equipment.

If the considerations outlined in the article are incorporated during the design stage of a chemical plant and followed up in the operational stage, it can be presumed that SAFETY in the plants is well catered for, does not rule out the need of continued vigilance to spot out hazards and take corrective action. Awareness of a hazard itself by plant operators, makes the plant operators safe workers.

"The manager is the dynamic, life-giving element in every business. Without his leadership the resources of Production remain resources and never become production."

—**Peter F Drucker**

Industrial Safety Needs Organisation and Planning

D.M. Patel*

In any modern industrial undertaking, the need for an effective Safety Programme can hardly be overemphasised. This is not only essential for prevention of industrial accidents and thereby reducing the incidence of injury and cost of cash compensation and medical care, but also indispensable for greater production and productivity. Among the various causes of industrial accidents, the three that are of primary concern are: carelessness or negligence on the part of workers; defective tools and equipments and faulty plant layout resulting into unsafe placement of workers on machines. Since prevention is always better than cure, a concerted safety campaign should be launched in every industrial undertaking. The basic elements of such a campaign should, among other things, consist of education and training of workers in industrial safety, strict compliance of safety rules and regulations, and recognition of the role of a qualified safety engineer in prevention of accidents.

INDUSTRIAL revolution and mechanisation has posed a serious threat to worker's life. Tremendous bill is paid each year for the treatment and cure of disabilities to workmen resulting from on-the-job accidents. Most of the bill is paid by the industrial concerns, large and small, employing the men when injuries were incurred. A statistical survey shows that between 1956 and 1963 there were on an average 1200 deaths, 5000 cases of permanent disabilities and 75000 temporary disabilities per year. As a result compensation at an average of Rs. 75 lakhs has been paid to the victims of the accidents. It has been realised by now that not only the workers who are the victims of accident suffer from it but other workers and employers also suffer because of these accidents.

Losses due to Accidents

Direct Losses : These arise out of the legal obligation of the management to pay compensation for injuries to workers. The visible expenses include the medical and hospital expenses, death benefits and workmen's disability compensation. These costs must come out of industry's profit since the responsibility has been placed by law on the employer.

Indirect Losses : These may arise from many sources. Firstly one man is out of production for several days, i.e. loss of productive time of the injured employee. Then his colleagues would gather around him and send him to the hospital. This may cause considerable loss of productive time. Moreover other employees may slow down work due to depressed feelings. This may also lead to loss of productive time of the foreman, supervisor and other executives because after the accident has taken place safety meeting may investigate the cause of accident and will have to prepare the accident report for the government agency. In some cases the accident causes damage to machine, tools and other property that will also add to the loss of production.

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In addition to this the injured worker suffers financially because his injury disability compensation never equals his earning except in some companies that have full-pay benefit plans. Moreover many injuries leave the worker permanently disabled and may prevent him from earning at the same level as he did prior to the injury. If despite his handicap his employer employs him at the same wages as before the injury the employer suffers a loss as long as the man is so employed. Either way there is cost penalty that may be assessed against someone.

The Need for Organisation and Planning of Safety Programme

Accident prevention is a vital factor in any industrial enterprise, one which if ignored or practiced unskilfully, leads to needless human suffering and business bankruptcy. So now-a-days in any industrial concern safety programme is attached much importance for many reasons. There has been tremendous industrial expansion and production processes are more complicated and diversified. Compensation benefits provided for the injured workers are increased by law, and medical and hospital expenses go on increasing day by day. Moreover organised labour has entered the field of safety and has demanded better protection for its members while on job. In any industry the programme to prevent accidents or to reduce them to a reasonable minimum and the organisation to carry on the programme must be intelligently planned. The results of a well-planned safety programme are lower production costs gained not only through reduction in injury, compensation and medical costs but also through the greater efficiency of operations and production per man that comes from the better morale of workers in a plant that has reputation as a safe working place.

Causes of Accidents

Before planning suitable precautions against accident it is necessary to know exactly how and why they occur. According to one authority accidents do not happen, they are caused by failure of one or more elements. Many times, however, human element is predominating. Sometimes an accident takes place due to violation of safety rules by somebody; e.g., if the cleaner forgets to wipe out the spillage grease from the floor, the result is somebody may get hurt. The violator does not endanger his life alone by violating the safety rules but he endangers others also. Industrial psychologists claim that though some of the accidents may be regarded as unavoidable, a majority of them can be predicted and to that extent they can be avoided.

The causes of thousands of accidents reveal three basic defects viz.,

(i) Improper acts
(ii) Improper tools
(iii) Unsafe positions.

Unsafe act includes the following:

1. Using unsafe or defective tools or equipment
2. Improper lifting
3. Unnecessary exposure to danger
4. Neglecting safety or protective devices
5. Operating equipment without authority
6. Making safety devices inoperative
7. Unsafe loading, placing, mixing, etc
8. Taking unsafe positions.

Unsafe mechanical and physical conditions include improperly guarded equipment, defective equipment, improper illumination, improper ventilation, unsafe dress or apparel.

Accident Prevention

Accident prevention is a valuable aid to production. It can be defined as an integrated programme, a series of coordinated activities, directed to control unsafe personal performance and unsafe mechanical conditions and based on certain knowledge, attitudes and abilities.

Basically the programme is the same for large or small establishment and all kinds of industrial activities. There are three basic principles:

1. Creation of and maintenance of interest to initiate prompt action.
2. Pertinent facts must be found out and analysed.
3. Corrective action must then be taken on the basis of well-selected remedies.

The task requires immediate approach and the longer-range approach of training and education. Emphasis is placed on the immediate approach, because it is a first as well as a continuing task, while at the same time it covers the essentials of safety education. The work of eliminating causes of accidents improves attitude of workers, which in turn increases the industrial productivity.

The three basic principles of accident prevention when applied as preventive method involve the following steps.

Step 1. Organisation

The safety organisation is the mechanism by means of which interest is kept alive and the safety programme is directed and controlled. In any industry the programme to prevent accident or to reduce them to a reasonable minimum and the organisation to carry on that programme must be intelligently planned. The actual work of prevention is done by line and staff supervisors with the support of management.

Step 2. Fact-finding

In this work the investigation of accidents for cause and remedy by the supervisor is the keystone. By combining this with the conclusions derived from surveys, inspections, experience, inquiry judgement, a method for collecting information on accident causation and remedy is established.

Step 3. Analysis

This describes the work of drawing conclusions, identifying the principal causes and types of accidents, the kind of injuries, the locations, operations, and equipment chiefly involved and persons who are responsible or who are affected. Analysis also includes the study and solution of problems when they obstruct the progress.

Step 4. Selection of Remedy

When the analysis of the facts of accident causation indicates need of some corrective steps, selection of an effective remedy becomes necessary. Just as a physician varies his prescription according to the cause and nature of disease, so does the safety engineer select his remedy according to the cause and kind of unsafe act or condition.

Step 5. Application of Remedy

Application of selected remedial measures is both immediate and long-term. Existing unsafe conditions and circumstances are attacked at once, while at the same time the programme includes procedures devised to anticipate and prevent situations of similar nature.

If personal performance is unsafe employees must be selected, trained, cautioned, persuaded, convinced and appealed to. In rare cases some form of disciplinary action is applied.

Fundamentals of Successful Accident Prevention

There are certain fundamentals that must be accepted by industrial management and which once accepted must continually be emphasized and filtered down from the top of the organisation to every level of management and supervision and to every job performed. The degree of success is dependent upon the degree to which these principles are sincerely accepted and actively promoted by management.

The principles are:

1. There must be a sincere desire by management to have an effective safety programme. The attitude of management will be reflected down through supervision to every job.

2. Participation must be so evident as to leave no doubt in the minds of subordinates about the attitudes of management. There is vast difference in the accomplishment of an accident control programme in which the management is visibly active and one in which there is passive acceptance of the idea but no active participation readily apparent to the work force.

3. The fact must be accepted that to prevent accidents money must be spent to provide safeguards, to plan and design safe operating process and procedures and to staff an adequate organisation to assist line supervisors in carrying out the safety policies established by the management.

4. There must be acceptance of the principle that the safety programme is necessary as a part of the production process programme. Therefore the same executives who are charged with the responsibilities of developing and directing efficient production methods must be held responsible for the administration of safety programme. The safety engineers are their staff advisors who assist them in meeting their accident-control responsibilities.

5. The management should place the accident-control programme and safety engineer staff on the same plane in the organisation of the company as other staff functions, such as engineering, industrial relations, accounting, purchasing and cost control. The safety programme assists all staff units except accounting function in carrying out their responsibilities

Safety Propaganda

Propaganda is an important part of selling safety. Posters, bulletins, safety competitions and audio-visual aids like films etc are useful means of safety propaganda.

Safety propaganda may be carried on by means of safety posters of different types, each helping to promote safety in its own way. Some may be humourous, some may give general advise and some others may demonstrate a particular hazard on a specific operation. Posters may be used to condemn bad habits, to show advantages of safe working or to give detailed information, advice, instructions on a particular point. A few appealing posters may be illustrated as:

1. They want you home safe
2. False eyes cannot see
3. Electricity is a good servant but bad master
4. Accidents subtract production, add to your pains, they divide your pleasures and multiply your worries
5. Where caution ends accident begins
6. Yama awaits those who have thrown precaution to the wind.

In some cases, safety competitions are held on the basis of indices of accident total frequency rates. A rotating shield is given to winning department to keep for one year, while the workers of the safety shield winning department are given individual prizes.

Educating for Safety

An active committee will work strenuously to have a better record than its neighbour, and once aroused, the men learn how to put the doctrine across. A competitive spirit keeps the members of a department or plant safety-conscious. As safety education never ceases, constant follow-up is required.

Normally instructions start when an employee reports for work. Every worker must be made conversant with every detail of his job. Because habits are developed through repetition, work methods should be constantly observed and improper methods immediately corrected. Whenever work methods are to be changed, employees should be prepared in advance, and adequate instructions should be given to assure a smooth transition from old way to the new.

Periodicals such as safety magazines are good means of getting messages across. Special bulletins, with adequate illustrations, may be put out to cover procedures in combating hazards. Motion pictures and other visual aids are of great value in safety education. While posters give one impression of hazard, a film tells the whole story of accident, showing how the dangerous situation arose, how the accident happened, what the consequences were and how it could have been prevented.

Safety Training

From analysis of accidents it has been acceptted that a large proportion of the accidents happen to people who are new to their jobs and have not yet developed safe working habits. The reasons for this are, most often the worker was not aware of the risk, and if he knew the danger he did not know how to avoid it. By proper training these sort of accidents can be avoided. Training of safe working is the training for efficient working. In some countries industrial safety education is given in schools and colleges so as to ensure that new entrants into industry have at least an idea of the dangers awaiting them and means by which they can avoid them.

Safety Enforcement

Safety propaganda alone cannot bring fruitful results. It is necessary that the safety programme is enforced. Worker's attention must be arrested and their interest must be kept alive. They must be convinced that accidents are preventable. The safety engineer must inculcate safety conciousness in supervisors and workers alike. Moreover the management must show its bonafides and give the workers confidence in its safety policy.

Safety Rules and Regulations

The government has laid down certain rules and regulations to ensure safety to workers. The Factory Act 1948 has placed responsibility for safety matters on the employer. He must comply with all safety provisions, without waiting for the inspector's instruction. The act also places legal responsibility on the management for the maintenance and use of proper guards. It is the duty of the employer to supervise the use of guards by the workers. Merely affixing notices or giving instructions will not serve the purpose.

Safety Engineer

Safety must be in the charge of a person who has basic knowledge of the working parts of machines, who is conversant with the operations of the machines, who can spot hazards and can successfully prevent them. Such a person should have engineering background, with added training in safety engineering. A safety engineer is a man conversant with production, but he is never loaded with production responsibilities. He specializes in safety knowledge, hazard detection and accident prevention. The safety engineer should act in an advisory staff capacity only. His only authority is to advise the executive and lower supervisors on problems encountered in providing safe working places and promoting safe practices. He should not have authority to issue orders to workers or supervisors. He is responsible only for the quality and reliability of the service, advice and assistance that he gives to line management. He must be sure that the advise he gives is sound and is based on the best known and most thoroughly explored theories and practices. Safety engineer has to look after the following points:

1. Any unsafe operation or working condition.
2. Potential hazards like storing of coal, petroleum, acids etc.
3. Inspection of defective tools.
4. Enforcement of safety equipment such as wearing of safety gloves, safety goggles protective clothing.
5. Safety training of personnel in fighting fire hazards, electric shock treatment, first aid training, wearing correct aprons etc.
6. Investigation of accidents, their causes and preventive measures etc.
7. Prevention of potential hazards.
8. Review of standing rules, instructions etc.
9. Safety propaganda.
10. Working out accident cost and statistical data.

Does the Safety Programme Pay?

Every industrial concern is aware of the cost of accidents. Practically all large companies have formally organised safety programmes. A statistical survey shows trend in accident reduction. As a result workmen's compensation costs, medical costs, lost time costs etc. have been lowered. Thus production cost is lowered. Remarkable improvement in worker's morale is seen, which will increase the productivity of labour.

Safety is not an entity separate from production. A safety programme must be coordinated and integrated with production programme. Safe practices should be followed even if they cost more than unsafe practices. Safety is a vital social and economic interest.

Plant Engineering Service—A Modest Beginning in N.P.C.

S. Ghosh*

In industrially advanced countries, Plant Engineering has already assumed a key role in enhanced productivity. In India, however, the concept is in its nascent stage both from the point of view of coverage and the level of sophistication. Nevertheless, over past few years, Plant Engineering, as a special branch of engineering—responsible for keeping the productive apparatus of an industrial undertaking in efficient working condition has been gaining ground in the Indian industry and efforts are now being made to develop it indigenously. In this endeavour, the National Productivity Council is most keen to render all possible assistance to the industry and for the purpose established, under its Fuel Efficiency and Technological Services Division, a separate section to cater to the needs of industry in the field of Plant Engineering. The scope of Plant Engineering Services of the NPC mainly consists of training and consultancy besides popularising the very concept of Plant Engineering throughout the industry.

ALTHOUGH many Plant Engineers are working for long in Indian Industries, the concept of Plant Engineering as a specific branch of Engineering is of recent origin in this country. In Western Countries and Japan, however, it has been accepted long ago because of its role in enhancing the productivity of an enterprise. It implies practical engineering with management implications rather than an off-beat academic and unrealistic approach. The commonly conceived image of the Plant Engineer as a maintenance man in grimy overalls is being replaced with the concept of the modern Plant Engineer who is an active and vital member of the management team—a practical yet educated man skilled in both engineering and management functions, and able to apply them to wide range of industrial problems.

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The responsibilities of the Plant Engineer vary enormously from plant to plant, depending on such factors as size, complexity and tradition. In a well-organised plant, the following are the important functions of a Plant Engineer (See Annexure I) :

1. Maintenance—Preventive, Routine, Breakdown, Major Overhauls and Repairs, aimed at protecting and preserving costly capital items and preventing their deterioration and to get the maximum utilisation from them round the year.
2. Utilities Engineering, including Instrumentation.
3. Mechanical Handling and Internal Transport.
4. Capital Works of Plants and Buildings.

5. Special Production Processes and Maintenance workshop.
6. Techniques of on-load repair and on-load cleaning of process and capital equipments.

The Plant Engineer's task is to discharge these functions as economically as possible, which means at minimum overall cost, resulting in wider profit margins in both short-term and long-term range.

Perhaps the most important responsibility of the Plant Engineer is to keep production machinery and equipment and all other plant operating facilities in efficient working condition at all times. For equipment failures are costly—costly in lost production, costly in profits, costly in lost manpower utilisation, and costly in customer relations because of inability to meet commitments. Hence the Plant Engineer must ensure prevention of such interruptions to plant operations. By performing his duties successfully, he can often assume an importance equal to Production Engineer since the latter depends on him to keep plant facilities operating. Especially in India where critical shortages of materials are encountered, proper plant maintenance can become even more vital, for the need of observing conservation practices with regard to hard-to-get tools and materials is uppermost.

The more complex, sophisticated or automated an industry is, the more responsibility the Plant Engineer has to shoulder; in fact, the functions of Plant Engineer assume comparatively greater importance in such a sophisticated or complicated industry.

In addition to his direct responsibilities, the Plant Engineer is also responsible for thinking out process development and improvements, giving valuable feedback to design engineers, advising management on plant replacement policy, reducing production rejects and scraps, improving material handling systems, etc.

In the present context of utilising the spare capacity in various engineering and process industries in order to increase our self-reliance, thus reducing avoidable imports of capital goods and raw materials, the role of the Plant Engineer is a very crucial and major one.

In fact, there is a direct correlation between the optimum utilisation of installed or licensed capacity of an industry and the efficiency of its Plant Engineering Department. The more organised and efficient its Plant Engineering Department is, the more prosperous or profitable a particular industry is bound to be. This fact is clearly borne out in our country if one were to make a survey of our industries. At one end of the spectrum we can see that most of the troubles of some of our major capital-intensive industries are mainly due to their inefficient and ill-organised Plant Engineering Department, whereas at the other end of the spectrum we can see that some of our refineries and most modern chemical complexes are working in an excellent manner because of the efficient working of the respective Plant Engineering Departments in these complexes.

In a recent article in the *Economic Times*, one correspondent has very aptly described the greatest technological problem faced by the Public Sector industries today in terms of maintenance. The prevailing methods of maintenance management are totally inefficient, ill-organised and ill-planned. This is equally true for many of our Private Sector industries. Being unaccustomed to complicated and sophisticated equipments, our Plant Engineers who have known crude methods make a mockery of the well-established techniques of maintenance. Major breakdowns of machinery and equipment are always traceable to sloppy maintenance.

Such costly inefficiency continues to persist in most of our industries due to the lack of porper appreciation and knowledge of good standards of maintenance and also for want of requisite skills. A recent study of the Bureau of Public Undertakings has shown the prevailing ignorance of the several units about maintenance and its usefulness. Planning or scheduling for maintenance is unheard of, let alone new knowledge of areas like tribology and terrotechnology. Preventive maintenance is also little known to most of our industries. Even where it is known in theory, it is little applied in practice.

We must do something to improve maintenance management in our industries. In recent years the management techniques have become more and more complex but their full use will be essential if we are to compete in this highly competitive world. Everyone knows such techniques are available. But can anyone say how many Plant Engineers use the following more established ones in their own departments:

1. Production Control (Maintenance Control)
2. Work study and incentives
3. Cost Control by comparison of actual costs with achievable standards.

It should never be assumed that these techniques do not apply to Plant Engineering—they most certainly do—indeed in all but the smallest Plant Engineering departments, they are indispensable, although, of course, their application has to be tailor-made to meet local requirements. But in order to exercise effective control over both performance and costs they are as necessary to Plant Engineers as they are to Production Executives.

Similarly one may ask how many Managements ensure that their Plant Engineers are provided with prompt, accurate and meaningful cost information? How many Plant Engineers ask for it and how many can understand and know what to do when they get it?

Plant Engineers must also ask themselves the following questions :

1. Is their department organised to give the most efficient service ?
2. Do men ever wait to be given the next job?
3. Are men held up for spares or materials, tools or equipments ?
4. Do technicians have the proper tools for the job?
5. How many maintenance men are under the control of Production?
6. Is all overtime really necessary ?
7. Is plant released by Production Dept. when required? And justified ?

An efficiently organised Plant Engineering Department is *sine qua non* for successful running of an industry. Hence greater attention should be given to run Plant Engineering service on a systematic basis so as to yield immediate and quick dividends to the industry. The National Productivitv Council of India (NPC) which has been rendering training and consultancy services in various techno-managerial disciplines finds that in order to improve the overall productivity of our industries, it is imperative to develop and offer its services in Plant Engineering as well.

Realising the importance of training in the field of Plant Engineering, NPC has immediately offered six training courses to industries covering some important aspects such as Plant Maintenance, Process Instrumentation., Industrial Electronics etc. NPC has now prepared a detailed perspective plan on Plant Engineering for the coming 3 years. This will help in deciding the line of action to be taken by NPC in the field of Plant Engineering so as to be of benefit and service to the industry.

The salient features of the three-year plan of action are as follows :

(i) It is proposed to conduct a National Seminar on Plant Engineering during the last quarter of 1973 or in 1974. This will help in drawing much-needed attention to the subject, offering a common platform for the men from industries, universities and institutes for discussing and identifying various problems in Plant Engineering. The holding of the Seminar is considered to be important in the context of the urgency of utilising the existing spare capacities in industries, which in turn is necessary for achieving self-sufficiency by the country. If we have to dispense with foreign aid and depend more on our expertise and calibre, we have to initiate a new awareness among our plant and maintenance engineers on the role they can play in this venture and also to locate the problem-areas where more efforts will be necessary for better performance. The National Seminar on Plant Engineering will focus attention on these needs and potentialities.

(ii) In the next 2 years, NPC proposes to organise region-wise or industry-wise seminars on Plant Engineering which will concentrate on the problems peculiar to the region or the industry, keeping in view the types of plants which are in use in the region or the industry.

(iii) NPC proposes to conduct training courses on Plant Engineering for personnel at all levels. Short courses on vital plant equipments such as pumps, compressors, valves etc. will also be organised.

(iv) For training of plant mechanics and supervisors, it is proposed to establish a Plant Engineering Laboratory. The Laboratory will not be a conventional workshop but will have separate sections on important aspects such as instrumentation of process plants, gears, packings, lubrication, vibration, etc. It is proposed to equip each section with samples, cut-away models, defective pieces (indicating the nature and cause of defects), charts, etc.

(v) Since the area of Plant Engineering is a vast one, initially it is proposed to develop expertise on the following important aspects of plant engineering:

  (i) Process instrumentation and control
  (ii) Utilities Engineering
  (iii) Computer Applications in Process and Plant Engineering
  (iv) Vibration Engineering
  (v) Techniques of on-load repair and maintenance of capital and process equipments
  (vi) Protection of equipments against chemical corrosion and erosion
  (vii) Maintenance Engineering
  (viii) Testing of Materials etc.

For this purpose NPC will undertake

the training of suitable qualified and experienced Mechanical/Chemical/Electronic Engineers and provide them with the know-how in the field of industrial engineering as well as specialisation in one of the above-mentioned aspects.

(vi) It is NPC's desire to develop close liaison with the industries in the field of Plant Engineering, with a view to ascertaining the problems of industries at first hand. It will be the endeavour of the NPC to adapt the well-established techniques practised in developed countries in the field of plant engineering to suit the local conditions and propensity of labour.

(vii) Finally it is proposed to encourage periodically and ona meaningful scale, workshop-cum-discussion sessions on important aspects of the subject among different plant engineers in various industries to examine the following areas :

1. Problems faced and solved by individual companies and engineers
2. Problems of topical interest
3. Import substitution drive and the results obtained therefrom.

The purpose of such discussions is to evolve over a period a mosaic of indigenous technical know-how in the field of plant engineering. NPC will undertake the responsibility of disseminating the knowledge thus gained by interchange of ideas among technical personnel through suitable measures.

REFEERNCES

1. Plant Engineering Handbook by Staniar—Mc-Graw Hill.
2. Maintenance Engineering Handbook by Morrow—Mc-Graw Hill.
3. Plant Maintenance Manual by Clement and Harrington—Chilton Book Co.
4. The Plant Engineer's Contribution to Management by H.A. Gomm. The Steam and Heating Engineer.
5. Technological Problems of Public Sector, *The Economic Times*.

Reliability Technology

Reliability assessment techniques for a wide range of industrial plants, which have been developed by the United Kingdom Atomic Energy Authority's Systems Reliability Service, are now being used by organisations in many countries to improve efficiency and economy.

Its techniques were being applied to mass-production engineering units, oil refineries, chemical plants, ships and aircraft—any of which could be regarded as an assembly of components liable to periodic breakdown. A total of 30 major projects had already been undertaken for industry in such fields as glass, chemicals and textile manufacture, atomic energy, power production, and fire and safety alarms.

—British Information

ANNEXURE I

Functions of a Plant Engineering Department

PLANT ENGINEERING

- **MAINTENANCE**
  - Preventive Inspections
  - General Maintenance
  - Overhauls
  - Breakdown
  - Maintenance of Plant, Equipments, Building & Grounds
- **SERVICES**
  - UTILITIES ENGINEERING
    - Process steam
    - Gas
    - Water
    - Electricity
    - Compressed Air
    - Waste Recovery
    - Waste Disposal
    - Instrumentation
    - Tool, Gauge and die making, Prototype and model making; Setting and adjusting Production Machine
  - TRANSPORTATION
    - Mechanical handling
    - Internal Transport
    - External Transport
  - SPECIAL PRODUCTION PROCESSES
    - Welding
    - Blacksmith work
    - Painting
    - Pipe Fitting
    - Carpentry
- **CAPITAL WORK**
  - Purchasing
  - Construction
  - Installation
  - Improvements
  - Removal
  - Disposal of Plant, Equipment, Building, Grounds
- **MISCELLANEOUS**
  - Safety
  - Fire precautions
  - Lubricant recovery
  - etc.

BOOK REVIEWS

PRICE INDEXES AND QUALITY CHANGE : STUDIES IN NEW METHODS OF MEASUREMENT. Edited by Zvi Griliches; Harvard University Press, Cambridge, Massachusetts; Pp. XII+287; Price $7; 1971.

Price indexes, such as the Consumer Price Index, do not take into account changes in the quality of products. They give, as such, a distorted picture of changes in prices and are, to that extent, misleading. To eliminate this lacuna, a new method of computing price indexes has recently been developed, which fully takes into account quality changes of products. The new technique, known as the "hedonic" approach, uses statistical regression techniques to derive relationships between prices and the qualitative aspect of a commodity.

The book, Price Indexes and Quality Change : Studies in New Methods of Measurement, is an excellent treatise on this technique of computing price indexes. It is in large part a product of the research stimulated by the Federal Reserve Board Price Committee in U.S.A.

The papers in this volume fall broadly into the following three categories : (a) A brief introduction by Griliches, the Editor of the book, and a theoretical discussion on quality change and its implications for the construction of price index numbers by Fisher and Shell ; (b) A set of papers outlining, applying and extending the hedonic (regression) approach to price change measurement, starting with the early Griliches paper on automobiles, continuing with Dhrymes, extension of it to include individual manufacturer effects and use principal components to cope with the multicollinearity of the various characteristics, followed by the Kravis-Lipsey application of it to international price comparisons of durable goods, and Triplett's study of the practical difficulties of implementing such suggestions routinely ; and (c) Papers on the use of secondhand market prices for the measurement of quality changes.

The papers analyse the theoretical and empirical problems involved in the measurement of price and quality changes. They include theoretical discussions of quality change and its implications for the construction of price index numbers, by Franklin M. Fisher and Karl Shell ; a series of four studies outlining, applying and extending the hedonic (regression) approach to price change measurement, by Zvi Griliches, Phoebus J. Dhrymes, Irving B. Kravis and Robert E. Lipsey, and Jack E. Triplett ; and two studies on the use of secondhand market prices for the measurement of quality change, by Phillip Cagan and Robert E. Hall.

The first paper is a comment on regression analyses of prices as practised today. It explores in some detail the promise and difficulties associated with the use of second-hand market prices for the measurement of quality change and examines the current state of practice in the official price indices.

The fourth paper—another one deserving special mention—is an empirical study of price and quality changes in consumer capital goods. Here, the author examines the feasibility of taking into account the factor of quality changes in the construction of price indices. A paper preceding it seeks to solve the problem in connection with automobiles by obtaining a cross-sectional sample of models produced by various manufacturers (for a given year) and then regressing list price on the various attributes of the model such as weight and length.

In this context, the following issues have been raised in the fourth paper : (a) What functional form describes best the relation between price and attributes ? (b) Is this price-attribute relation homogeneous among manufacturers ? (c) How are the coefficients of such a relation best described ? (d) Is it feasible to construct routinely "quality corrected" price indices ? (e) What do the empirical results indicate about the intrinsic price movements of such commodities, taking "quality" into account?

The book provides at one place ready access to what has already been accomplished in the field. It also stimulates thinking for further research on the theoretical and empirical problems involved in the measurement of price and quality change. That is why the editor, Zvi Griliches, modestly accepts that it raises as many questions as it answers. But then this is true of any research study. The book is of immense interest to researchers in econometrics, for whom it is meant.

—AC VYAS & HARTIRATH SINGH

GHERAOS AND LABOUR UNREST IN WEST BENGAL By K.N. Vaid, Shri Ram Centre for Industrial Relations & Human Resources, 5 Pusa Road, New Delhi-110005; Pages 252; Price Rs. 30

No doubt, since the phenomenon of *gherao* erupted in the wake of the United Front rule in West Bengal in 1967, quite a few studies, some inspired, but all motivated, have been conducted to understand and interpret the problem. Several articles, research papers, and pamphlets have also been published on the subject. Nevertheless, a systematic and objective study, according to the reviewer, was conspicuously absent. Mr. Vaid has, therefore, done well to fill in this information gap. The time-lag involved seems to be a blessing in disguise, in the sense that it has enabled both the researchers and the parties concerned to have a more closer and objective look at the issues involved.

The work, however, was not easy. Only 210 firms out of 803 (affected by *gheraos*) offered cooperation. The labour put in, and the interest evinced, by the research team is clear when one is told that the field work for the study involved visiting all the enterprises that suffered '*gheraos*' to study the patterns of their ownership and operations, management structure and practices, state of trade unionism, past history and current status of union-management relations, quality of implementation of labour laws, working of joint Committees and social background of workers and managers.

The difficulty did not end there. In view of the nature of the record-keeping of the firms, the data remained uneven, in both quality and comprehensiveness, and, therefore, not amenable to comparison. Hard facts were not easy to get. Opinions, as could be expected, were available in plenty, which were of little use to an objective assessment of the situation. It is gratifying to note that "most of the party and union leaders whom the team approached gave their time and discussed issues frankly and dispassionately". Secondary data have been made use of wherever found necessary.

The findings of the study have been very ably and competently drafted and presented in the volume under review. What is more interesting is the attempt made by the author to have a wider perspective of the entire gamut of the system of industrial relations and bring into the fore the major operational defects at various levels. In the process, Mr. Vaid has no brief for any particular 'pressure group' and has exposed them (if one is permitted to use the term) in the deserving manner. He has also highlighted some of the unpalatable truths.

For instance, Mr. Vaid minces no words in stating that "so long as workers are denied the enjoyment of their rights and privileges created by law or through law courts, there can be no peace in industry. Further, unless workers feel that they are partners in prosperity and have a stake in enterprises along with employers they are unlikely to develop constructive attitude towards industry."

Elsewhere the author has focussed another equally important facet of the problem. "Because of their non-local origin, high earnings, and professional concerns, managers in West Bengal's industry retain a psychological barrier *vis-a-vis* the local community. By and large, they are only marginally involved in the social and economic problems in the region. The community, therefore, is denied the wider benefits of the high-cost talent".

In refreshing contrast to the generally held views on *gheraos*, Mr. Vaid has sought to indicate that "the practice of professional management in West Bengal was the principal beneficiary of the *gherao* movement". And it was through these back pressures that the implementation of various statutory provisions and tribunal awards improved, formal wage policies were introduced, personnel function was accorded a better recognition, grievance procedures were given more serious attention and managements, in general, became more humane in their response to labour.

Mr. Vaid has also tried to provide an answer as to why the workers lay their tools down instantly and recklessly. To quote him, "A strike, an act of indiscipline, absence from work for a week or a month—how much do these things cost a worker in Calcutta ? He has nothing much to lose. His standards of living is so low that the difference between working and not working, makes only a marginal impact on his standard of living".

In brief, what the city offers to its residents by way of civic amenities and social services degrades human dignity, outrages the sense of decency, and creates in men attitudes of despair, anger, hostility, and cynicism. It might be asked as to why should a person internalise the norms of a system which offers him nothing better than a sub-human existence ?

Then what is the solution ? Mr. Vaid feels that if we can render the concept of equity a living reality, make enterprise structures more open and flexible, and, above all, provide enlightened leadership not only at the top of our governments but also in responsible positions in industry, trade unions and universities : In short, if we have skills to manage change, then we can contain industrial conflicts and social tensions and hope for an orderly development of our society. Unfortunately the "if" is really a big 'if'.

A pains-taking and thought-provoking study indeed!

—KSV MENON

FOREIGN TRADE REVIEW : UNCTAD III Special Number (Oct.-Dec. 1972) Published by Indian Institute of Foreign Trade, H-24, Green Park Extension, New Delhi-16. Pages 330 Price Rs. 5.50

No one in the know of things can deny that within its short span of existence of less than a decade, UNCTAD has proved its worth in more ways than one. The UNCTAD-III Conference at Santiago, held in April, 1972, saw that it had moved from the stage of identifying problems and possible solutions to the stage of forcing the developed and developing countries to the negotiation table for sorting out the problems in an equitable manner for the common good of the international community. Undoubtedly, the advantages flowing from the activities of UNCTAD are far-reaching, not fast but slow, more invisible than visible and yet, it is not surprising that it often invites criticism from both the sides. Developed countries accuse it of radicalism while developing countries which, in many cases, are fighting for their very economic existence, let alone economic growth, feel that the organisation is not moving fast enough. Thus, UNCTAD is getting a beating from both sides but its ability to produce a rhythm to please the ears on both sides and deliver the goods is not in doubt.

The present issue of the 'Foreign Trade Review' devotes itself to an examination of certain areas of international trade in the light of what has been achieved or could be expected of the UNCTAD as an agency. The Secretary-General of the UNCTAD seems to be not happy with the performance at the Santiago Conference when he observes that "On the whole, the results of the Conference were not commensurate with the magnitude of the present-day development problems nor with the serious efforts made in its preparation." The Conference regrettably did not result in a general agreement among all the countries participating, because it happened by chance to have been held during an unsettled situation of the international monetary system and world trade affairs. It was, however, reconfirmed that the economic aid from the advanced countries to the developing countries was to be at the rate of one per cent of the total gross national product of the advanced countries in the period 1972-75. It was also agreed that the amount of government aid was to be increased by 1975 to the rate of 0.7 per cent of the GNP of the advanced countries. These decisions went far to relieve the anxiety of the developing countries about their economic development which seemed seriously impeded by the chaotic world economy and the disorderly trends in international trade.

A total of ten papers included in this Special Number usefully takes us through a vast vista of foreign trade in relation to the activities of the UNCTAD. Released after the Third Conference, naturally the publication has taken note of the proceedings at the Conference. Different contributors assess the role of UNCTAD in a wide range of perspective. It appears that self-reliance through regional cooperation should be the lesson learnt from UNCTAD III by developing countries.

In the field of technology, the stage is now set for developing action-oriented proposals for improving the access of the developing countries to sharing in the accumulated treasure-house of world technology. Surendra J. Patel feels that it is not easy to assess in any simple manner the results of the third Conference in the field of transfer of technology. The resolution passed at the Conference on the subject, however, could serve as a charter for improving the access of developing countries to technology.

This publication will be treasured by all those who are interested in developing international economic relations amongst countries of the world.

—Navin Chandra Joshi

COMPARATIVE STANDARDS FOR ENGINEERING INDUSTRIES, Published by Engineering Association of India, India Exchange, Calcutta, Pp xv+208; Price Rs. 50

Standardisation is an important tool of industrial and economic progress, for it provides a common language and criteria for judging the value of goods and services and establishes methods by which they can be put to optimum use. It ensures quality of products by setting forth quality levels for the whole range of industrial activity—from raw materials, through semi-finished products, to finished goods. This leads to wider acceptance of products manufactured in accordance with standards, thereby opening up ever new markets for them at home and abroad. In international trade, standards eliminate ambiguity and stimulate increased exchange of products and technology from one country to another.

In India, the post-Independence era has witnessed phenomenal growth of industry, especially in the engineering sector. Performance in the export market, however, depends to a large extent on the exporters' capability to identify the standards to which the items for export must conform. The Engineering Association of India has answered this long-felt need by bringing out the volume under review which gives, product-wise, designations of standards most commonly mentioned in trade inquiries received from overseas buyers. The compilation lists Indian, British, Soviet, Japanese, German and American standards for 162 engineering products in an alphabetical order. The range of products covered extends from gas to generators and spanners to sewing machines. Some of the other products covered are air cleaners, belt conveyors, capacitors, diesel engines, electric motors, fire-fighting equipment, hand tools, hoses and conduits, lubricating oil, marine light fittings, piston rings, road and rail bridges, safety razor blades, steel castings, storage batteries, trailers, valves and vices.

A valuable reference book, the publication will be of great use to Indian exporters in identifying foreign standards in their line of interest and help them in sending expeditious response to export traders.

—D.S. Johar

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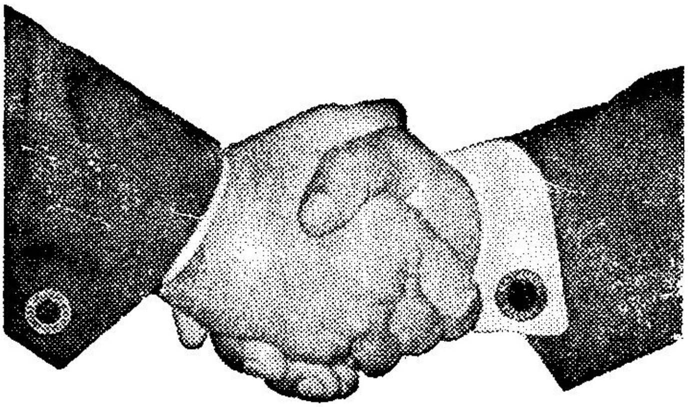

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	Pages
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National Productivity Council	104
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Warner Hindustan	106

PRODUCTIVITY

SUPPLEMENT

Vol. XIV No. I

Sharing The Gains Of Productivity And Productivity Agreements

SEMINAR REPORT

In Retrospect

The National Productivity Council (NPC) has been seriously examining for the last ten years, what should be the appropriate share in the gains resulting from higher productivity of the various partners in the production process and of the consumers. In 1960, the NPC organised a Seminar on "Co-operation for Higher Productivity and Sharing the Gains of Productivity"

Arising from the recommendations of the Seminar, an Expert Committee, under the Chairmanship of Shri Naval H. Tata, was set up in October 1960, by the President of the NPC, to examine the principles which should govern the distribution of the gains of productivity. The Naval Tata Committee presented its well considered views in a working paper. The Governing Body of the NPC appointed another Committee in October 1963, under the Chairmanship of the Late Shri Leslie Sawhny, to examine this working paper and make specific recommendations with particular reference to the gains that should accrue to labour.

The Sawhny Committee, after serious deliberations in seven meetings, submitted its report in January 1967 to the Governing Body of the NPC. The Report contained a proposed National Formula for Sharing the Gains of Productivity which did not, however, receive unanimous acceptance.

Realising that it might be difficult to evolve an unanimous national formula for sharing the gains of productivity, Governing Body of the NPC felt that instead of evolving a National formula, efforts should be directed to suggest at the national level broad guidelines for sharing the gains of productivity duly supported by such illustrative "models" or schemes of sharing the gains as have been successfully tried by Indian enterprises in Indian conditions. With considerable perseverance and thought the Governing Body of the NPC has succeeded in preparing such guidelines, along with supporting illustrative "models". Ever since, these guidelines and 'models' have been rendering practical assistance to industry and labour in evolving their productivity policies and negotiating, on a bipartite basis, such agreements on incentive schemes and productivity as would lead to better performance, higher productivity and increased benefits not only for labour and industry, but also for the community at large.

The recent seminar at Trivandrum, held on February 1, 1973 under the joint auspices of National Productivity Council and Kerala State Productivity Council, was yet another thought-session on the subject to further crystallise the thinking on such an important issue as sharing the gains of productivity.

Seminar on Sharing the Gains of Productivity And Productivity Agreements

(Trivandrum, February 1, 1973)

INAUGURAL ADDRESS

By Shri Vakkom Purushothaman*

I am happy that Kerala State Productivity Council is hosting the National Productivity Council's Annual Conference on the 2nd and 3rd February, 1973 here, and as part of it, it has also sponsored a regional seminar on Productivity Agreements and Sharing the Gains of Productivity, which I feel honoured to inaugurate today. May I congratulate the sponsors on their commendable endeavour to organise the Conference and regional seminar outside Delhi so as to bring about a good gathering of well-known Managements and Trade Union practitioners, specialists and thinkers in various fields and representatives of Government under one roof to discuss the productivity problems relating to economic reconstruction of the country. I am also thankful to them for affording me an opportunity to participate and join in their collective thinking in this seminar on the very intricate but exciting field of activity.

Admittedly, our country has reached the crucial stage of break-through for development. No doubt, contradictions and conflicts inherent in the process of development have emerged, posing challenges to leadership—political and bureaucratic—saddled with the functional responsibility of planning for progress. While on the one hand, India has made tremendous progress in the field of agriculture, through green and white revolutions, and in the field of manufacturing industry as evident from the range of articles displayed at the recent "ASIA 72", the country is, at the same time, baffled by the slow pace of resource-mobilisation, near-stagnation in the industrial field, spiralling inflationary pressures, population explosion and the growing swell of unemployment. The scale of effort and the size of sacrifices called for from the people in order to achieve a measurable progress in the country are too evident to require repetition. In absolute terms, the investment order of 50,000 crores of rupees envisaged in the

*Minister for Agriculture and Labour, Kerala.

Plan document for the Fifth Plan of the country is massive ; but relatively to the needs of the people, the amount contemplated is undoubtedly small. Even in our State, with peculiar problems of its own, we have planned for an investment of the order of Rs. 1,903 crores, with the State sector outlay amounting to Rs. 705 crores.

Improvement of the standard of living is contingent upon three factors :

(a) Job opportunity ;
(b) Balance between real wages and money wages ; and
(c) Availability of large range of consumer goods.

The job opportunity which is conditioned upon the investment—potential and actual—becomes meaningless, if the real wages are eroded by inflaction in the economy and, as a result of which, there has been a fall in the money value. Further, the money accruing from a job must be swapped against something that is available. It pre-supposes that there must be adequate availability of consumer goods. Productivity assumes greater importance in an economy which is short of investible funds for further expansion on account of certain constraints—naitonal, political and economic. Increased productivity in different sectors of economy would enlarge the availability of the goods and at the same time provide a cushion against the rise in prices. It also brings about a balance between the real wages and the money wages of the workers. Moreover, increase in productivity would result in higher wages to the worker which would make for better standard of living. Higher productivity can be brought about through three ways :

(1) Improvement in the efforts of factors of production;
(2) Avoidance of waste ; and
(3) Utilisation of unused installed capacity.

All the three are not independent of one another. All these factors may co-exist either to make for improvement in productivity or hinder the effort towards it.

The country now needs higher productivity in the sphere of agriculture. I am emphasising the aspect of agriculture not because I am a Minister in charge of agriculture too. What the Approach Paper for the Fifth Plan says supports my above view. To quote it :

"In the Indian situation, possibilities of creating substantial additional wage-employment by changing the product pattern of manufactured goods in a labour-intensive direction in the organised sector of the economy appear to be rather limited. Similarly apart from encouraging multiple shifts, the possibilities of creating additionl demand for wage-labour through economically permissible changes in technology in this sector would also appear to be small. It is more promising to think of generating additional employment by undertaking area-based land improvement programme or by giving incentives to small units".

At the present pace of industrialisation, any mass scale transfer of the labour force from agriculture to non-agricultural has to be provided with fuller employment within agriculture itself. Fuller employment in effect means reduction in underemployment. This can be brought about mainly by increasing the productivity through proper utilisation of resources.

Productivity Policy turns on (a) a rational wage policy, and (b) method for sharing of productivity gains. Rational wage policy must proceed from the fundamental concept that workers would have to be paid the need-based minimum wages. We have to recognise that human being is an important element in the factors of production and proper motivation and improvement will go a long way to make him efficient. If you are to pay price for machines to be properly looked after, it is understandable why a human machine should be ignored. There is a need for reorientation of our approach towards the up-keep of workers. Fair wages which provides and accommodates the needs arising from the new social order should be adjusted to the productivity and the worker should have the proportionate share in the gains resulting from the improvement in productivity. This involves a proper incentive wage system with a fall back wage which is a basic minimum of subsistence. Secondly, our traditional approach towards worker needs to be given up. The worker should be regarded as a participative factor in the Management. This means we have to provide for participative management where the workers have decisive say in the managerial affairs. Thirdly, the old know-how has to be replaced in keeping with the technological revolution that is going on. It is unreasonable to oppose the introduction of automation and computarisation *per se*. However, the introduction of such automation should not lead to the displacement of job oppurtunities and cause hardship on account of shifts in places or modes of work. Further, automation should also lead to the ancillary development creating vaster employment potential in the economy and reduce the cost.

Sharing of the productivity is the crux of the problem. Three parties are involved in the sharing : (1) Labour, (2) Management, and (3) Consumer. Till now, the productivity increase by way of net value added to manufacture was appropriated by the management, by and large. Only recently a share is given to the worker by way of bonus. The bonus concept that has been evolved in India partakes of two characteristics : (i) deferred wages, and (ii) participation in prosperity. Both concepts are combined in an expedient way and provided in the present Bonus Act. But bonus is adventitious to the windfall gains of a particular unit on account of price factors. But bonus does not take into account the continuous improvement of a unit on account of shift in the tastes of the consumers and enlargement of the consumer choice, inprovement in the net national product and technological revolution. So, there should be a proper provision for continuous sharing of the productivity between the Management and the workers by virtue of Productivity Agreement. The norms, the method and the *modus* for such a sharing will have to be evolved. We cannot ignore the consumer at large while discussing about sharing of productivity. Consumers have a stake in our countrywide improvement in productivity, because it is through their sacrifices, productivity gains, to a considerable extent, are sustained and achieved. The share has to go to the consumer by way of price decrease or/and qualitative improvement in the product sold.

Thus, there is a need for a national approach to the problem of productivity and its share and such an approach should be simple, equitable and flexible. I commend the following issues for the earnest consideration of this distinguished gathering :

(1) The problem of productivity has to be looked upon as a human problem with emphasis on human efficiency and has to be

dealt within the matrix of indurtrial relations system.

(2) Improvement of techniques making for productivity is fundamentally the responsibility of the Management and such improvement should involve an incentive wage system with the proper motivations built-in, based on group norms. This should replace the outmoded system of time-rate payments.

(3) Industrial discipline should be seen as a cooperative endeavour or co-determination and not as master and servant relation based on qualified contract.

(4) Motivational system to be evolved must cover :

(a) recognition of human personality ;

(b) encouragement for personality involvement ;

(c) admonition and warning, substituting for punishment ;

(d) collective participation ;

(e) elimination of factors conducive to personality alienation.

(5) Productivity Agreements should replace the age-old method of Wage Agreements, pure and simple. Distribution of productivity should be proportional to the capacity of the industry.

(6) But such productivity sharing should be more or less equal between Management, workers and the consumers at large.

(7) Bonus concept should be redefined to mean continuous sharing of productivity and not as a share in the prosperity of an adventitious nature. ●

KEYNOTE ADDRESS BY CHAIRMAN

Shri K.T. Chandy

The National Productivity Council is a forum where labour, management and Government come together for making collective effort to raise productivity in all spheres of our economic effort. There is a fourth element in the National Productivity Council, namely, experts; association of experts are given representation in the Council. Being a forum where representatives of organised labour, employers or management, Government, and experts get together, the Chairman of NPC has to function as the spokesman of the group and hence the necessity to confine myself to matters on which there is a concensus in the Council.

The subject before us is "Sharing the Gains of Productivity". This is an issue on which NPC has sought to focus the attention of the public since 1960. Agreed arrangements for sharing the gains of productivity have to be built into productivity agreements for such agreements to gain acceptance and achieve faithful implementation, The same kind of idea can be seen to be at work in the plans we prepare for the Nation as a whole. The Planners have said that growth must be integrated with redistributive justice. The fruits of growth must be available to all sections of the people, and weightage has to be given in the distribution of income to those who are below the poverty line.

As we need the support of all factors in production in raising productivity, NPC found it necessary to bring together these different elements in a committee to study the problem. The NPC organised a conference on the subject in 1960. Pursuant to the recommendations of the conference, an expert committee consisting of representatives of different groups was appointed in October 1960, under the chairmanship of Shri Naval Tata. This Committee presented its views in the form of a working paper. NPC appointed another committee in October 1963 under the chairmanship of late Shri Leslie Sawhni to examine the report of the Naval Tata Committee and to make specific recommendations, as to the gains that should accrue to the labour. The Leslie Committee reported in January 1969. Its report set out formula for sharing the gains of productivity. Unfortunately as the formula did not find the unanimous acceptance in the NPC, the Council appointed another committee in July 1968 under the chairmanship of Shri Kashinath Pandey. The Pandey Committee submitted its report and *inter-alia* suggested that the Government of India should pass appropriate legislation for establishing productivity norms and other related standards and for giving directives and awards on sharing the gains of productivity. Even these recommendations did not find unanimous acceptance in the National Productivity Council.

In the light of the above developments, the Productivity Council finally decided to place before the public typical productivity agreements which have actually been entered into between management and labour over a period of time. While there may be no national consensus yet on sharing the gains of productivity, it is encouraging to note that in a number of enterprises, agreements have been reached between labour and management on this subject. The models now placed before the public by NPC are model only in the sense that they typify the different types of agreements so far entered into. These models are now before you for your critical examination. The concensus that we seek in this field has to be built in each individual organisation or enterprise in the light of its own special position.

It occurs to me that every State should insist that all such agreements entered into between management and labour in particular establishments should be lodged with the authorities. An archive of this nature would thus provide the material for further critical examination of the process by which a consensus is emerging on sharing the gains of productivity. In the documents circulated by NPC and in the Hon'ble Minister's speech this morning, reference has been made to certain principles which should guide the sharing of gains of productivity. I shall make a few comments on these principles.

It has been said that the major responsibility for sharing the gains of productivity is with the management. I think that the term "management" as used in this context, should be understood to mean the function of management. Those who perform this function include not only those who are in charge of individual business enterprises, but also those who manage the economy as a whole, namely, those who are in public administration. If the productivity of the managerial group engaged in public administration is low, the productivity of the economy as a whole will also remain at a low key. In an environment in which the State has to play a decisive role in the planned development of the economy, efficiency has to be high in public administration. These days we want a measure of labour participation in management. Consequently, we have to understand that the term "management" as used in the NPC document implies all those who exercise or influence the function of management. I believe that labour is an instrument of and agency for productivity. The more they are ready to participate in management, the more they have to participate in making productivity a success. A socialist society requires socialist discipline.

As to the co-sharers in the gains of productivity, there is wide acceptance of the view that, not only management and labour, who are the internal components of the industry, should get the benefits, but also the public for whom economic enterprises exist. In popular language, this has been expressed in the statement that the consumer is entitled to share in the gains of productivity. The term "consumer" as used here does not mean only the individual who requires various items for maintaining a reasonable standard of living, but also industries and all economic activities, because many economic activities draw their requirements from other sectors of economic activity. Agriculture requires the inputs of industry. Industry in turn requires the outputs of agriculture. Some industries require all that other industries produce. In this view of the matter, it is the economy of the nation as a whole, that is the external element who is entitled to share in the gains of productivity of any particular unit.

The Hon'ble Minister referred to the need for raising productivity in agriculture. This is indeed true. The NPC may not immediately engage itself in all aspects of this issue. However, it is open to the NPC—in fact it is necessary on their part to do so—to look at the productivity of those industries which provide the essential industrial inputs for agriculture as fertilisers, pesticides, and agricultural implements. It is also necessary that the Council should look at the productivity in those industries which use agricultural produce as their basic raw material ; such industries are those based on cotton, jute, oil seeds, food processing industries, etc. Productivity in agriculture can only be raised when the productivity of the industries that provide lateral support to agriculture rises in equal measure.

I am happy to have this opportunity of welcoming all of you to this conference and I hope that through your deliberations you would enlarge the area of consensus on the means of measuring productivity and on the manner in which gains of productivity should be shared. ●

SUMMARY OF PROCEEDINGS

In the first business session that followed the inaugural session, productivity agreements were discussed. Shri **Krishna Pillai** took the Chair of the first session. He raced the history of the transformation of collective bargaining to productivity bargaining and the evolution of productivity agreements. He mentioned about the Fawley agreements and the radical recommendations made by the Royal Commission on Trade Unions and Employers'

Associations in UK on changing parttern of collective bargaining. He mentioned the need for evolving a price-income and wage-policy and the need to remove the restrictive practices. In the Indian conditions it is necessary to restructure completely our industrial relations machinery if we have to increase productivity through collective bargaining. These hurdles are to be removed. The litigious and legalistic approach to labour relations should be given up. In spite of the various hurdles existing in the country a number of industries successfully concluded productivity agreements and implemented them. It has considerably benefited the labour as well as the industry. It has helped to increase the wages of the workers in other industries where the agreements are successfully implemented. In the present context of the industrial relations in the country and due to the problem of determining the proper bargaining unit, it may not be possible to have a nation-wide or industry-wise agreements. However, the factory and unit level agreements can be worked out and be implemented successfully both for the benefit of employees and employers. There can be no rigidity in laying down a fixed formula for sharing the gains of productivity. It has to be worked out by mutual agreements at the unit levels.

Shri S.K. Warriar, Personnel Supdt., Indian Aluminium Co., Alwaye, presented a paper on the rationale of productivity agreements. He was of the opinion that productivity was hampered due to human factor, especially the attitude of the human resources at various levels in the country. The restrictive practices are the impediments for increasing productivity. He explained the various guidelines for the productivity agreements in the light of productivity agreements entered into by the Indian Aluminium Company and the benefits accrued to the various parties concerned. He also gave examples of other agreements resting in the industries in Kerala.

Shri S.C.S. Menon, a prominent trade union leader of Kerala, explained the various types of incentive schemes and the productivity agreements which has been entered into by his union at the various industries. He explained many instances where these productivity agreements and incentive schemes are working very satisfactorily. However, he also mentioned certain cases where the schemes have not been a success because of the manner in which the managements treat the labour and allow them to participate in the endeavour to increase productivity.

Shri R. Baktha, O & M Officer of KCP Ltd., Madras, explained productivity agreements with which he was associated in their preparation and implementation. He explained the various procedures involved in evolving such productivity agreements and the structure of such agreements. He also explained the guidelines recommended by the National Board for Prices and Incomes in UK which were worth considering in drawing up the productivity agreements.

During the second and third Technical Sessions, **Dr. G.R. Dalvi,** Executive Director, National Productivity Council, took the Chair. Papers by Shri **S.K. Maini,** General Production Manager, Motor Industries Company, Bangalore, **Shri R.S. Gupta,** Secretary, National Productivity Council, New Delhi, **Shri K.P. Sachindranath,** a prominent trade union leader from Bangalore and also Hony. Secretary of Mysore State Productivity Council, **Shri M.M. Jacob,** Regional Director, National Productivity Council, Bangalore and **Shri T.A. George,** General Manager, Hindustan Insecticides Ltd., Udyogamandal, were presented.

Shri Maini explained the comprehensive scheme of sharing the gains of productivity evolved at MICO. He explained in detail the three components of the scheme, i.e. (a) incentive schemes (b) motivational activities and (c) three-yearly productivity agreements. He enumerated the prerequisite for the success of such a scheme. He further explained how this scheme has benefited the employees, managerial people and employers. He said that the prices of the products produced in his company is less than those existing in the developed countries and that his company has not increased the price of the products during the course of last 10 years.

Shri R.S. Gupta explained the guidelines for sharing the gains of productivity as illustrated in the NPC document. He said that this is only one of the studies which NPC has taken up so that the industries which are interested could benefit by studying these schemes existing in the various industries in the country. He also informed that NPC has decided to collect the various productivity agreements existing in various industries and analyse them with a view to evolve the models for implementation.

Shri K.P. Sachindranath explained the need for obtaining the need-based wages and the recommendations of the wage policy board to safeguard the real wages of the workers. He said that the industrial relations machinery be developed so that an effective co-operation between labour and management could be brought out for increasing productivity. Trade Unions can play a constructive role in drawing up the productivity agreements.

Shri M.M. Jacob, in his paper, indicated the increasing number of social responsibilities and obligations which the business and industrial organisations have to shoulder and the challenges the management and the technocrats hav to take up to meet the increasing demand. He explained that the instrument of long-term planning at unit levels will help considerably in meeting these challenges and improve productivity and contribute towards increasing wages.

In the paper of **Shri T.A. George,** incentive scheme in operation at Hindustan Insecticides as a part of the productivity agreements was explained. It is a multi-factor scheme by which the performance of the organisation is kept up considerably high. The paper was read by **Mr. Sulaiman** of KSPC.

Shri K.T. Chandy, in his concluding remarks, emphasised the need for making the process of productivity endeavour a continuous one. He explained the responsibilities to be shouldered by the National Productivity Council and the Local Productivity Councils in compiling and analysing the various productivity agreements employed by the industries in the country with a view to make available a comprehensive document on the subject and also evolve the models and guidelines suited to our situation. He explained that in the present context and also according to the guidelines prepared by Planning Commission for the fifth Five Year Plan, the investment should go to such areas and spheres so that more and more goods are available to those who are below poverty line and also to provide more employment opportunities to them. The Gains of Productivity in organised sector should be distributed in such a manner that it accelerates the above process. It is high time that we earnestly grapple with the problems before us and arrive at an acceptable solution and take necessary decisions and actions.

PAPERS PRESENTED AT THE SEMINAR

1. Concept of Productivity Agreement

2. Rationale of Productivity Agreements

3. Raising the Productivity and Sharing its Gains

4. Models for Sharing the Gains of Productivity

5. Distribution of Productivity Gains

6. Productivity Agreements—A Trade Union Point of View

7. Productivity Incentive Scheme in Hindustan Insecticides Ltd.

8. Pre-requisites for Sharing the Gains of Productivity

9. Productivity Agreements—A Case Study

Concept of Productivity Agreements

P.N. Krishna Pillai*

It was in U.K. that the productivity agreements saw the day in early sixties when a comprehensive union management contract was signed in ESSO Petroleum, aiming at increased productivity. In essence productivity agreement is a modified collective agreement whereby workers agree to make a change or a number of changes in working practice, leading in itself to more economic working and in return the employer agrees to pay to workers either higher wages or improved benefits. The basic difference between a productivity agreement and a collective agreement lies in the fact that while in the latter wages are more or less linked with cost of living index and inter-plant comparison of wages, in the former they are linked directly with the contribution of workers towards higher productivity.

The terms "PRODUCTIVITY AGREEMENTS" and "PRODUCTIVITY BARGAINING" became current in Labour-Management literature after the spurt of Comprehensive Union-Management contracts in the United Kingdom in the Sixties aimed at increasing productivity. The first in the series of these Productivity Agreements was the one in Esso Petroleum : Fawley Refinery followed by Esso Petroleum in distribution, Electric supply industry, Imperial Chemical Industries, British Oxygen, Alcan and several others. The Royal Commission on Trade Unions and Employers' Associations presided over by Lord Donovan had made very many radical recommendations on changing the pattern of Collective Bargaining in U.K. and on negotiation binding contracts between trade unions and managements aimed at increasing productivity. Due to drift in wages and the decline in economic growth the United Kingdom was going down in economic stability. Government adopted a prices and incomes policy which regulated the increase in wages. Any wage hike as a result of collective bargaining had to get the clearance of the National Board for Prices and Incomes. That clearance was given only when the wage increases beyond a minimum were justified by increases in productivity. The Board periodically conducted studies on productivity bargaining and productivity agreements and reviewed whether these agreements were bringing desired boost in productivity and growth in economy as a whole. The National Board for prices and Income in their report No. 36 submitted to Parliamant on June 7, 1967 says :

> "By a productivity agreement we mean one in which workers agree to make a change, or a number of changes in working practice that will lead in itself—leaving out any compensating pay increase—to more economic working and in return the employer agrees to a higher level of pay or other benefits."

*Chairman, Kerala State Productivity Council.

Productivity Criterion

The productivity criterion laid down in the white paper on prices and incomes allows pay above the norm "where the employees concerned, for example by accepting more exacting work or a major change in working practices, make a direct contribution towards increasing productivity in a particular firm or industry". No pious promises by unions or managements to endeavour to achieve better performance were enough. The contribution by labour must be direct and specific. The Prices and Incomes Policy is still undergoing changes but the trend in collective bargaining towards productivity agreements has taken roots in the U.K. Productivity agreements are different from conventional types of collective bargaining agreements. In the latter, cost of living increases and inter-plant comparison of wages etc. are taken into consideration for wage adjustments in the negotiations. In the former only workers' direct contribution by more exact working or agreeing to remove restrictive work practices alone entitles them for wage increases.

Reforms in Industrial Relations

In the Indian conditions, we have to completely restructure our industrial relations machinery if we have to increase productivity through collective bargaining. In our country wages and conditions of service are not by and large determined through collective bargaining. The present industrial relations law has nurtured a culture of litigation in labour relations through courts and tribunals. We are not only far away from productivity bargaining but are nowhere near any sort of bargaining relationship at all. The present legal system and structure in industrial relations is counter productive. Mutual trust and confidence essential for a productivity-oriented labour-management negotiations are absent. The multiplicity of unions with over-riding jurisdiction has further bedevilled the situation even in undertakings where modern managements endeavour to build up sound industrial relations based on direct negotiations. In my acceptance address in 1966 on the occasion of receiving Sir Jehangir Ghandy Medal for contributions made to industrial peace, while appealing for a change in the legalistic and litigious structure of our industrial relations, I had stated that "whatever settlements can be gained in industrial disputes through courts of law, it has never been the experience of any one that court decisions could achieve higher productivity. On the other hand, it has been the experience of firms even in India, that to gain the co-operation of workers in attaining higher productivity there is need for a tradition of Collective Bargaining". Many are the hurdles today in adopting collective bargaining as an industrial way of life. First, the employers should institutionally recognise unions and believe that they could be used for channelising the energy of the workers for better and efficient functioning of the undertakings. Second, there should be a legal basis for resolving the problem of recognition of unions. Third, the growth of splinter unions should be arrested and law should aid in building up of strong independent unions. Fourth, it should be made an unfair labour practice not to bargain in good faith with recognised representative unions. Fifth, the legalistic and litigious approach to labour relations should be given up. The National Commission on Labour had submitted its report in 1969 suggesting these and other measures to encourage collective bargaining but no concrete steps are hitherto taken to achieve the goal of substituting the present vicious system by a democratic system of industrial relations. So long as the structure of industrial relations in our country is not thoroughly overhauled, collective bargaining, not to speak of productivity bargaining, is a far off cry.

An Instance of Productivity Bargaining

In spite of these handicaps some of the progressive corporations in our country have taken a lead in fostering a tradition of collective bargaining. In quite a few of them, attempts have been made to link remuneration of working people with productivity increases. In Kerala itself, in one of the basic metal industries, where collective bargaining is practised, a productivity agreement has been entered into in 1962, almost simultaneously with the Fawley agreement in U.K. and almost on the same line. I had a part to play in planning and conducting these negotiations. Previous to that, a comprehensive work measurement and job evaluation was done by a firm of consultants. The union was constantly consulted. As a result of negotiations the union agreed to accept method changes, mechanisation and rationalisation of crew strength. The company, which was then in expansion process on its part, agreed not to effect retrenchment. During the last ten or eleven years productivity index has gone up by 400% from 8 tons per man-year to 32 tons per man-year. During the same period wages have also increased by over 300% from Rs. 217 per month to Rs. 680 per month. It is true that the increase in production was mainly due to expansion of the plant and addition of equipment for which the company had to make large capital investments but the fact remains that higher productivity was made possible with little or no increase in labour-force because the workers willingly took up increased responsibility for which they received adequate compensation in the form of higher wages and other amenities. This resulted in better management controls and harmonious industrial relations. The plant had not a single work stoppage in the last 17 years. This instance was cited only to point out that in spite of hurdles, progressive managements could achieve higher productivity through productivity bargaining even in our country. There are other such instances in Kerala and in the country as a whole.

Aims of Productivity Bargaining

In the guidelines and illustrative models on sharing the gains of productivity published by National Productivity Council the instances given are mainly incentive payment schemes. Productivity bargaining aims at more comprehensive gains than those achieved through incentive payments. I do not deny that in the present context in our country incentive payments have a role to play in boosting up productivity. Only I want to point out that productivity bargaining is wider in its scope. Productivity bargaining has to be planned properly and has to make a departure from conventional bargaining; even in the case of the productivity agreement in the metal industry in Kerala, cited above, a great deal of planning was undertaken. Both the management and union agreed in 1959 that a comprehensive study should be done by an agreed firm of consultants with a view to increase productivity and rationalise crew strength. The study took almost two years and throughout the study the union officials were kept in the picture. The negotiations with the union took more than six months. Instead of bringing issues relating to higher productivity by management at the time of negotiating a charter of demands presented by union in an ad-hoc manner, a pre-planned approach by both parties will yield better results. In all the instances of productivity agreements in the U.K. a lot of preplanning, study and discussions on the shopfloor took place before the managements took their schemes to the negotiating table. A lot of informal discussions with union leaders beforehand will also facilitate formal discussions at the negotiations. The management in productivity bargaining endeavours to reduce overtime, achieve flexibility in deployment of labour, eliminate restriction upon the pace of work, utilise manning most efficiently and change work patterns which clog the wheels of production. In most factories supervisors use overtime not as a means of dealing with emergencies but as a regular arrangement to provide an acceptable pay packet. This situation has to be changed primarily because the acceptance of overtime implied a loss of control by management over the pace at which the work has to be undertaken. As stated in the Fawely Blue Book, systematic overtime is symptomatic of managerial inefficiency. Flexibility is freer exchange of tasks between different groups of workers. This is often opposed by craft unions. In India though craft unionism has not so much spread its evils, strong caste systems have developed in categories of workers. This flexibility, which is called multicraftism, in Cochin Refineries in Kerala, has contributed to productivity. Instead of attending to minor repairs in machines worked by production workers, they wait for long intervals downing the machines for maintenance crew to attend to these rapairs. Voluntary restriction on pace of work is noticed in some workshops. Question of efficient manning is the central feature of any productivity agreement. At Fawley, the reduction of craftsmen's mates was a major element in the initial agreement. The system of mates or helpers (as in India) for craftsmen should be done away with. In the Kerala plant referred to above, which negotiated a productivity agreement in 1962, the system of helpers to fitters, welders, painters, machinists etc. was eliminated. They were trained to do other useful jobs. The usual practice of taking more time than necessary for clocking, in canteen and washing up at the close of work should also be eliminated. The aid of industrial engineering to arrive at necessary crew strength and to do job evaluation has to be resorted to in the planning period itself. In the U.K., because of the changes made, the number of grades of pay has been considerably reduced. This was particularly true of Alcan where forty grades were reduced to seven only. It is not possible to elaborate all the restrictive practices current in the industry that a productivity bargaining endeavours to eliminate. Similarly a more efficient management control system also emerges out of these changes.

In a developing country like India one important thing that should not be lost sight of is that the workers value stability and security in employment more than anything else. As in the case of the Kerala Metal Industry, an assurance should be given that no retrenchment would be effected as a result of efficiency bargaining. Mechanisation should also be resorted to with caution and with a sense of awareness of social environment. The principles adopted in a resolution on 'rationalisation without tears' by the 15th session of the Indian Labour Conference in 1957 should be adhered to as far as possible.

Bargaining Unit

It is often asked what is the bargaining unit for the successful bargaining for productivity gains. Is it an industry or a factory or a company? In the U.K., industrial bargaining used to be on conventional pattern. The Donovan Commission has stated that industry-wide agreements cannot, in collective bargaining, effectively deal with "incentive schemes, regulation of hours actually worked, the use of job evaluation, work practices, and the linking of changes in pay to changes in performances, facilities for shop stewards and disciplinary rules and appeals". They have expressed their preference to factory-based or company-based agreements. In India too, a few of the productivity agreements that are negotiated are mainly factory-based ones. In Japan where collective bargaining has developed after the second world war, the pattern of negotiations is one based on an undertaking and not one based on industry. Therefore one can safely say that a factory or company-based negotiation is more conducive to productivity agreement rather than an industry-based negotiation.

No Rigidity in Sharing the Gains

The National Productivity Council, after elaborate studies by several committees, has come to the conclusion that there cannot be any ready-made formula on sharing the gains of productivity. It should vary from plant to plant, depending on the reduction in unit costs, the nature of the industry, the investment in machinery and equipments by management, the market condition and various other factors such as the state control on prices in a country like India. However, it is agreed on all sides, that the gains should be shared by labour, management and consumers. In a report in 1967 on Productivity Agreements in the U.K. by the National Board for Prices and Incomes, the following observation was made on the question of sharing the gains of productivity:

> "To lay down a rigid rule of one third to the worker, one third to the employer and one third to the consumer would kill many valuable agreements from the start and permit the exploitation of the consumer in other cases".

The jugement must be made on the facts of each case. However, the customer should never be lost sight of.

A Management Responsibility

As stated in the publication of NPC on "Guidelines for Sharing the Gains of Productivity" the task of increasing productivity is primarily a responsibility of management. Unless the employer creates a climate of mutual trust and confidence among employees and a tradition of collective bargaining and joint consulation is built up, productivity bargaining will not be possible. A legalistic approach as discerned at present in labour-management relations is the least helpful factor to increase productivity. The necessity for developing professional management to achieve the goals of increased productivity cannot also be overemphasised. I know of instances where, as a result of productivity agreements, workers produced more; they had to face lay off due to lack of adequate marketing skills or quality control or proper maintenance of machinery. What is the attitude of trade unions towards productivity bargaining ? Whereas in the U.K. with long tradition of collective bargaining, it is observed by study groups that unions were receptive to the idea of productivity bargaining, the same cannot be expected in India where the whole culture of industrial relations is one based on litigation in courts. At the same time, a few of the productivity agreements successfully restricted in the country show that in a proper atmosphere the unions will respond to the idea favourably. Only the social environment should not be lost sight of. The unions will, in the long run, realise that for increasing the standard of living of the working class as well as to arrest the evils of mounting inflation, they have to generate more wealth by producing goods and rendering services more efficiently. The conventional bargaining has its limitations. As the President of Poland said recently, the workers can share only the wealth they produce. "You do not get anything by dropping a bucket into an empty well". The above is not the statement of a crusty corporation President or a desperate plant manager but of I.W. Abel, the president of the mighty United Steel Workers' Union in the U.S.A. In steel, the United Steel Workers and major producers have a joint programme to improve productivity and strengthen the industry's ability to compete with foreign steel makers. Abel told unionists bluntly that their next pay increase would depend upon better output. If this is the approach of leaders of workers in affluent countries in the West and Socialist countries towards productivity, it is high time that unions in developing countries like India took a more realistic attitude towards productivity bargaining. "The cake has to be baked before it is shared" is an old adage.

Prices and Incomes Policy

Before concluding, let me try to underscore the prime responsibility of the state in this regard. Every leader in the country shouts from housetops the need for higher productivity. Mere pious and wishful statements from platforms won't yield any results. Positive steps ought to be taken. In the first instance, the mess in the area of industrial relations law has to be cleared. The policy should aim at building up strong and representative trade unions. There should be a law on recognition of unions. It should be made an unlawful labour practice not to bargain in good faith with representative unions. As a second step there should be a prices and incomes policy which should ensure that any wage increase beyond a specific take-home pay should be based on productivity. The Government have urgently to address themselves to these two aspects in the areas of industrial relations and prices and incomes policy if the economic situation in the country is not to deteriorate further.

Filling the Communication Gap

A major problem of bigness and rapid expansion is the loss of contact between top management and lower level employees. Although company newspapers, bulletin boards, and group meetings are used by management in an attempt to maintain communications with employees, they fall far short of the personal feedback that executives need to determine the real problems that exist in the workforce.

One approach that has proved effective in helping to overcome this problem is the executive rap session, during which management and its employees discuss an issue with complete candor and openness. This helps to diffuse potential labour relations problems and uncovers virtual flood of suggestions that are of value to the overall operation.

This informal give-and-take discussion is conducted by a senior executive, accompanied by a personnel or employee relations officer, who can assist by taking notes on key points and providing expertise on personal policies, procedures, and practices when such matters come up.

—MANAGEMENT REVIEW

standing orders) and collective agreement etc. and the informal system actually existing on the shop-floor, which may be totally different from the former. Wages may be fixed in the agreement but the actual employees earnings may be determined by incentives and overtime earnings. Work standards might have been fixed by industrial engineering studies but the actual work norms prevalent on the plant-floor may be totally different. Besides, many other time-wasting and restrictive work practices and employee attitudes indicated earlier will be existing in the actual arena of work. It is the responsibility of management (and management only) to bring about a change in these attitudes and practices and to achieve higher productivity.

Management Responsibility

Productivity can be increased by (1) better application to work (2) working in better organised ways and (3) by using more productive tools and equipments. The essential thing is that unit cost of production decreases when productivity increases. In the endeavour to increase productivity and reduce unit cost management has to take the initiative. The managers have to be equipped with uptodate knowledge of modern techniques. In a progressive organisation there should be an atmosphere of continuous learning. Management has to create and maintain an attitude of receptiveness and adaptability to new ideas ; it has to promote and sustain a desire to innovate purposefully.

Productivity increase involves changes in materials, products, machinery, layout, quality requirements, time standards, work methods production processes, management techniques etc; these changes are introduced with a view to increase productivity and may include improvement, simplification, standardisation, specialisation, diversification, rationalisation, mechanisation, automation etc. It is not easy to accomplish these changes. Difficult processes of adjustments in age-old beliefs, deep-rooted traditions, confirmed attitudes and fixed work habits are often necessary.

Resistance to Change

A socially beneficial change from steam locomotive to diesel may be desirable from the view-points of passengers due to convenience, railways due to economy, diesel manufacturers due to new opportunities, but it will be difficult to be accepted by the men operating steam locos, the firms manufacturing steam locos and the men working in such firms. When rivetting is substituted by welding as a joining method, a number of companies will have to change its methods and equipment and a large number of craftsmen will find that the skill they have acquired through years of effort is of no use any longer. For the latter this change cannot be anything but frightening when they think of their job, their livelihood and their families' welfare. We cannot expect them to be calm, far-sighted and self sacrificing. Changes resulting from the impact of new ideas and techniques like Work Study, O & M, Industrial Engineering, Operations Research etc. have contributed to progress but they are surprising and deflating to the pride of those in charge of an activity or operation and frightening and insulting to the dignity of those workers who are told that for years they have been engaged in a useless and unnecessary job. It is bound to be emotionally devastating to be told that a job that has been done by 10 men can, with a little thought and planning, be done equally well or better by 7, 5 or even 3 men. The resistance to change arises not only out of the inherent inertia of all and the imaginary apprehensions of some, but also due to the real hardships of those who are directly affected. Unless these are tackled in a pragmatic way, bringing about changes will be difficult.

Restrictive Practices

Restrictive practices arise not merely from deep-rooted habits, attitudes etc. and from the desire for long-term security but also from a need to compensate for the unsatisfactory nature of many jobs and uncertainty. It is very necessary to remove or mitigate the psychological causes. A simple buying-out operation will not prevent the recurrence of certain work group characteristics. Even with new sophisticated equipments and work practices aimed at short-term increase in efficiency, it is necessary to design environments and jobs likely to give long-term motivation. All this implies the need for specific management expertise.

Skill of Management lies in the capacity of managers to channel industrial conflict into constructive lines, influence employees to change their attitudes, to create a situation when restrictive practices are minimised and to increase productivity with involvement and even commitment of employees. While the managers are trained and equipped to solve the technical problems of production, quality, cost, maintenance, research and development etc., usually they are not so well-equipped to tackle the human problems—social, organisational and psychological. They prefer to have as little as possible with employee relations and are eager to delegate them to a personnel manager. But the fact remains that the majority of problems that an industrial manager encounters are personnel in character and only a minority technical. Labour disputes intrude into their realm more often than technical problems. Labour problems are looked upon as a nuisance, a disturbance diverting their attention away from what they regard as the more important aspects of their work. A disciplined workforce and trouble-free relations are the industrial manager's idea.

The changes in the social environments of business enterprise, the increasing complexity of human problems in large organisations, the need for involving employees in bringing about changes, problems of motivating people to improve performance and the desire for participation in management—all these demand managers with knowledge and farsight.

The time has gone when a good engineer or a good accountant or a good salesman or a good public relations man will make a good manager. Gone is the time when men could rise to the pinnacle of industrial administration, to wield immense influence over peoples' lives and the nation's destiny without possessing any of the qualifications or qualities that are regarded as essential for lesser positions of responsibility in public administration or in the professions.

Total Management Concept

The whole management and not only personnel management is concerned with people at work and their relationships within an organisation. Personnel management cannot be viewed in isolation; line management blaming personnel managers for labour troubles or vice versa is typical of managerial irresponsibility. Personnel Managers pretending to be apostles of labour welfare, the advocates of people's feelings and aspirations, the embodiments of social consciousness and advisers of good human relations are equally nonsensical. The primary responsibility of industrial relations managers is to get men to work more and more productively. The industrial relations function should be a built-in, continuous, fully-integrated part of the total management effort. Industrial management, credited with many innovations in technical and commercial spheres, has been curiously slow to innovate in the field of industrial relations. They left the whole field for the unions to take the lead in agitating labour disputes and for the government to bring in a plethora of legislations without themselves assuming the leadership. The time has come for management initiative in the field of industrial relations and collective bargaining.

Collective Bargaining—Politics of Industry

Conflict situation exists in industrial relations because both sides of industry carefully observe how much power, influence, authority, income and wealth is at stake and will concede only the minimum ground deemed necessary to secure an agreement. This has been well-termed as the Politics of Industry by Allan Flanders. The effort should be to turn the politics of industry to its economics.

Historically speaking, there have been three patterns of Union-Management negotiations, which also represent three stages in the development of collective bargaining practices. The *conventional approach* to collective bargaining has been one of unions taking the initiative and putting forward charters of demands and the management trying to give out nothing or as little as possible. The managements' refusal to concede anything results in strained industrial relations, work stoppages and disruptions of productive operations. Even when management concedes something and get an agreement with minimum possible benefits to employees, the approach is negative. No attempt is made under this approach to get anything from labour, by way of more work, higher output or better quality in return for the benefits given. In short, there is only give and no take—a one way traffic. The bargaining is done by the Union unilaterally and the Management attitude is defensive. The idea underlying the attempt to get an agreement with the union is that it will create a peaceful climate where management can function efficiently to get the results. But it has been the experience that under this approach much of the productivity potential of labour remains untapped. This negative, defensive and unilateral approach does not help to attain higher productivity. Even when long-term, comprehensive agreements are concluded, establishing an orderly relationship between management and union by spelling out their rights and responsibilities, laying down terms and conditions of work, instituting grievance handling procedures and setting up joint consultative machinery to settle disputes, the emphasis has been on getting industrial peace and not achieving higher productivity. At best a pattern of industrial relations based on this approach may help to prepare the ground for achieving higher production through management efforts, the workers remaining passive.

A more modern approach which was subsequently developed and tried by some companies has been successful in taking the Union-Management negotiations one step ahead by introducing agreed incentive schemes which have helped to establish an identity of interests between Management and labour for increasing production. In order to counter the demands of unions for additional benefits, managements began asking for higher productivity (more work, better performance, higher output, improved quality etc.). They converted the negotiations from one-way traffic to two-way traffic, involving not only 'give' but also 'take'. This transformation of bargaining from unilateral to bilateral process was a welcome development. Though the approach remained defensive, by and large, considerable gains in productivity could be achieved. In return for higher wages and better conditions of employment for labour, managements began bargaining and getting higher productivity—more work in return for better benefits.

The productivity approach attempted during the sixties is characterised by management initiative in collective bargaining. Under this pattern, managements offer specific wage increases and other benefits (generally much larger than what are normally offered during negotiations for long-term contracts) in return for specific contributions from employees to achieve higher productivity. This is a positive, dynamic and novel approach to collective bargaining which should be adopted on a much wider scale in the interest of higher productivity and faster economic development.

Forward Looking

Productivity Agreements attempt to achieve concrete results from the agreement through a clearly defined set of measures. It is not concerned with past performance or vague promises for the future. Productivity bargaining lays emphasis not in compensating labour for past increases in the gains accrued through higher output or in sharing the benefits that have accrued in the past but it aims to increase output in the future with the conscious participation of labour and their unions and gives increases in earnings after productivity has risen. This approach is universally applicable to industrial establishments, commercial businesses, public utilities, administrative services and other areas of economic endeavour.

Unit-based

Problems and circumstances of different establishments vary widely; hence agreement suitable to one may be totally inappropriate in another. Therefore productivity agreements have to be essentially unit-based and not industry-wide. Control of measures and assessment of results in terms of input and output are easier and clearer only in self-contained, inter-related work place, i.e. a plant or office.

Specific Proposals for Negotiation

Productivity bargaining is nothing but orderly, objective and factual collective bargaining with specific proposals for increasing productivity and avoiding restrictive practices worked out in great detail and presented to the union as management proposals for negotiation. The characteristic feature of productivity agreements has been to make work practices more flexible by integrating more than one job, major or minor, abolishing wasteful systems of labour utilisation like providing helpers, non-working chargeman etc., transferring men from one job to another as work requires, avoiding systematic overtime and so on and upgrading the integrated jobs as a consequence and as a reward to higher productivity. Usually special payments and cumbersome allowances are merged into the basic wage structure (Productivity agreements have to be based on a rational and equitable wage structure). Many productivity agreements have emphasised job security, extended staff status and conditions to some or all of the manual workers and ensured annual guaranteed income, improved pensions and fringe benefits to employees. In modern sophisticated industries the distinction between direct and indirect, productive and non-productive workers is disappearing rapidly. Improving the productivity of work both in the plant and in the office deserves our serious attention now. Productivity agreements should aim at getting the involvement of all employees to be successful.

Guidelines for Productivity Agreement

1. Workers should agree to contribute towards the achievement of constantly rising levels of productivity; where appropriate, major changes in work practices or work methods should be specified in the agreement.

2. Measurement of productivity or efficiency should be based on the application of relevant indices of performance or work standards (fixed by Work Study).

3. A realistic calculation of all the relevant costs of the agreements (including cost of study, redundancy payments etc.) and of the gains attributable to the worker's contribution should normally show that the effect is to reduce the total cost of output or the cost of providing a given service.

4. There should be effective controls and information systems to ensure that projected increases in efficiency are achieved and that higher pay or other benefits are given only when such increases are achieved.

5. There should be clear benefits to the consumer by way of a contribution to stable or lower prices, improved quality, export earnings etc.

6. An agreement applying to one group of workers only should bear the cost of consequential increases to other groups, if any have to be granted (e.g. agreement with workers and consequential benefits to supervisory staff).

7. Negotiations should avoid setting levels of pay or conditions which might have undesirable repercussions elsewhere or at other times. (Even when justified, negotiators should consider the possibility of phasing the increases over a period of time or of making a non-recurring lump-sum payment. Failure to do so might raise expectations for future increases which would not be fulfilled).

(Adapted from the Report of the National Board for Prices and Incomes, U.K.)

Industrial Relations Climate

For concluding productivity agreements, an atmosphere of good employee relations is absolutely essential. Without good morale in the organisation and proper motivation of the working people achievement of higher productivity is almost impossible. Good employee relations policy can be established only by adopting certain positive measures in which management plays a vital role. A strong representative trade union acting as the sole bargaining agent of all the employees will be of immense help, though it has been found from actual experience that multiplicity of unions need not stand in the way of building up sound industrial relations especially in a highly productive industrial unit. Union-Management agreements of a long term character stipulating terms and conditions of work such as work standards, wage rates, dearness allowance, incentive bonus, overtime wages, fringe benefits, termination benefits, welfare amenities, leave, holidays etc. help establishing such a relationship. The contract should also spell out principles of recruitment and promotion, rights and responsibilities of management and unions, grievance handling procedure, mechanics of joint consultation, method for solving differences, including those on the agreement etc.

Participation in Decision-Making

Effective joint consultation is a prerequisite to meaningful productivity bargaining. Formal consultative machinery is not enough. The participants must have accurate and adequate information. And consultation should take place before decisions are made by management. For this the union representatives should be given all data that is necessary. To effectively utilise the data they should know a great deal about modern management techniques. A well-trained union representative can not only participate effectively in making vital decisions concerning the workers but also substantially contribute to their well-being through productivity bargaining and joint consultation on productivity problems.

Impact on Real Incomes

Effective productivity bargaining is one of the very few ways open to industry to stimulate greater efficiency and to enhance employee earnings without inflation. The rising prices in our country is really eroding the purchasing power of his income and his standards of living. Higher money income does not enable him to have higher consumption levels. Higher consumption of goods and services will be made possible only through higher productivity and increase of earnings related to productivity. In this sense productivity agreements will not only protect the real income of employees ; they are the only means of enhancing the real income of workers.

Productivity Agreements—Not a Panacea

Any manager who believes that once-and-for all productivity agreement can permanently remove all restrictive practices would not be realistic. High earnings resulting from such agreements will provide reasons for new defensive working arrangements, since the workers will naturally wish to protect a high paying job. Besides, work practices of industrial life are continually being made out-of-date by technological changes. Inevitably some time will elapse before they are detected and negotiated about. Hence vigilant revisions of agreements will become necessary and productivity bargaining will have to be done on a continuous basis.

CASE STUDIES

(a) Fawley Productivity Agreement (U.K.)

A large number of productivity agreements have been signed in the sixties starting from the celebrated Fawley Productivity Agreement.

Fawley Refinery of Esso in July 1960 published its productivity proposals in the form of a Blue Book to be discussed and debated by its 3300 employees covered by eight unions and simultaneously announced the offer for a 40-45% wage increase and a 40-hour week with one condition that the increase in wages would be phased to follow the achievement of productivity objectives such as the following:

(i) reduction in overtime (ii) eliminating craftsman's mates and redeploying them on other jobs (iii) abolishing craft demarcations (iv) transferring minor maintenance work from craftsmen to process workers (v) getting greater freedom in the use of supervision (vi) abolishing unproductive allowances such as tea breaks, washing time, walking time etc. (vii) eliminating special payments like heat money, dirt money etc.

In a period of two years they achieved 45-50% increase in productivity, besides a reduction of overtime from 8 % to 18%.

(b) West Coast Longshore Agreement (U.S.A.)

An agreement signed in October, 1960 between the Pacific Maritime Association and the International Longshoremen's and Warehousemen's Union, brought out restrictive union work rules, under safeguards against unsafe conditions, onerous workloads and individual speeding up, by the offer of a substantial trust fund to be used principally to finance early retirement benefits and a no-lay-off guarantee to a fully registered labour force.

(c) A Light Metal Company of India

Employing about 1000 men achieved a three-fold increase in productivity and a corresponding increase in the emoluments of employees through a series of productivity agreements concluded from January 1960 to February 1965. The points negotiated include fixation of better work standards, rationalised crew sizes, reduction of idle time and wastages, avoidance of restrictive practices, consolidation of job categories and grades, elimination of helpers in some cases, entrusting minor maintenance and cleaning to production workers, work simplification, method improvement, streamlined material handling systems, better planning and scheduling methods, new layouts, reorganisation etc.

The Struggle for Achieving Higher Productivity

These achievements in establishing productivity-oriented employee relations were the result of long and concerted effort put in over a number of years. The difficulties involved can be understood only if we go a little deeper into the cases cited. To illustrate the point, the experience of our own company, which after initial struggles went about on an endeavour to establish higher productivity and better industrial relations, may be relevant. Job Evaluation scheme was adopted as early as in 1948 to resolve wage inequities. An incentive scheme introduced in 1957 by signing the first long-term agreement went a long way in establishing an identity of interests between management and labour in higher productivity. The long-term agreement, signed after a bitter strike, helped to develop an atmosphere of mutual trust and co-operation. From 1957 onwards the Company encouraged a number of union officials to undergo training courses in productivity techniques. In the second long-term agreement signed in 1960, it was agreed that Work Study and Job Evaluation would be conducted on all jobs to increase productivity and enhance employee earnings.

Preparing the Ground

With a view to secure the active and understanding co-operation of all levels of workers and supervisors, an intensive campaign to educate them was undertaken through:

(i) departmental meetings,

(ii) classes for Shop Stewards and members of the Executive Committee of the Union and representatives in Joint Committees,

(iii) unit level classes on workers' education,

(iv) house magazine, and

(v) film shows.

The Union nominated a representative for every section of the plant for maintaining liaison between the workers in that section and the consultants. The Company's Industrial Engineer did the coordination between the departmental staff and the consultants.

During the study, the findings were continuously discussed with the management and Union.

Job descriptions and specifications drafted by the consultants and the Company's Industrial Engineer were discussed in detail with departmental staff and union officials before finalisation. The scheme for Evaluation was earlier finalised in consultation with the parties.

Negotiations and Implementation

The work study and job evaluation reports formed the basis for Management-Union negotiations which took about six months in which all details were thrashed out threadbare. The manhours spent on negotiations far exceded the manhours taken for the study. A large amount of understanding of each others' problems were exhibited by both parties. When tentative agreements were arrived at on all major points, the negotiations were adjourned to enable the union to explain them to the workers in a series of section meetings and to get the approval of the general body. The elaborate procedure followed in discussions and negotiations during the studies and negotiations were designed to effectively communicate changes to the rank and file workers and to bring out resistance earlier than later.

When the agreement was signed, it was agreed that 637 employees will do work which was being done by 826 employees even though the work study findings had indicated that it could be done by 580 employees. The surplus personnel were to be utilized for work in a new plant being set up. But since there was a time lag between the signing of the agreement and the commissioning of the new plant, surplus personnel were allowed to stay at home and receive the full salary for some time, when they were not needed to work in rotation with the others retained. The implementation of the agreed points was done through a joint committee consisting of management and union representatives in a phased mnner.

Follow-up

Though the union could agree, in the first instance, only to much lower standards than those recommended, they had promised to progressively endeavour to achieve the recommended standards and to further increase productivity later on. This was done in a series of steps and by 1964 all the major standards recommended were accepted and implemented.

A further attempt to increase productivity on the above lines was made in 1965-66 after signing the second productivity agreement in early 1965. The plant capacity was expanded three-fold during this period. The increase in productivity and employee earnings during the last few years in this company is given in Table II.

TABLE II

	Productivity Index	*Average Employee Earnings*
1956	8 tonnes/ manyear	Rs. 214/- per mensum
1961	12 tonnes/ manyear	Rs. 351/- per mensum
1966	24 tonnes/ manyear	Rs. 504/- per mensum
1971	32 tonnes/ manyear	Rs. 833/- per mensum