

CHAPTER 2

Auditing Human Factors in Maintenance Management

Introduction

In the first chapter I have drawn on an audit of a food processing plant to discuss maintenance strategy, organisational structure and systems. The models on which that analysis was based were derived from the work of the administrative and systems theorists (see Table 2–1), rather than from the school of managerial theory which is centred on studies of *human relations*. We will now look at how human factors can influence the way in which maintenance work is carried out and how they can be audited.

What are ‘Human Factors’ in Organisations?

An organisation is a system of interdependent human beings, and their characteristics affect both its structure and its functioning. Human relations management studies the characteristics and inter-relationships of individuals and groups within organisations and takes account of these factors when designing and administering those organisations.

The Human Relations Approach to Management—A Brief Review

The first major development in the human relations approach was the work of Elton Mayo at the Hawthorn Plant.¹ He established that social and psychological factors were important to worker satisfaction and productivity. Considerable advances were made during the period 1950–70, most notably by Maslow, Herzberg and McGregor, in understanding worker motivation.^{2–4}

Maslow identified and ranked what he considered to be the needs of the individual, i.e.,

¹ E. Mayo, *The social problems of an industrial civilization*, HGS & A, Boston, 1945.

² A. A. Maslow, *Motivation and personality*, Harper and Brothers, New York, 1954.

³ F. Herzberg, *One more time: how do you motivate employees?* Harvard Business Review, Jan/Feb 1968.

⁴ D. McGregor, *The human side of enterprise*, McGraw Hill, New York, 1960.

TABLE 2.1 Summary of Management Theories

Mechanistic management—monitors and controls the way the job is performed at shop floor level; includes method, timing, and direction.

Administrative management—applies universal management functions and structural principles to the design of an organisation and to its operation.

Human relations management—studies characteristics and relationships of individuals and groups within an organisation and takes account of these factors when designing and administering it.

Decision management—applies procedural and quantitative models to the solution of management problems. A theory for communications and decision making in organisations.

Systems management—studies organisations as dynamic systems reacting with their environment. Analyses a system into its sub-systems and takes account of behavioural, mechanistic, technological and managerial aspects.

Contingency management—takes the view that the characteristics of an organisation must be matched to its internal and external environment. Since these environments can change it is important to view the organisational structure as dynamic.

Higher needs	5. Self-fulfilment
	4. Autonomy
	3. Self-esteem
Basic needs	2. Sociality
	1. Security

Herzberg also divided the needs of the individual into those that are basic (biological) and those that are higher (growth). He then identified and quantified the factors affecting these needs, see Figure 2–1. He pointed out that it is the factors bearing on the higher needs that can affect job satisfaction and that, in the industrial setting, these are to be found in the job content. Factors which influence the basic needs are those affecting job dissatisfaction and these are concerned with the job environment. He emphasised that it is the factors which bear on the job content that are the true motivators and that a motivated worker is responding to an internal stimulus—he wants to get the work done.

McGregor's work—his so-called 'Theory X' (the then traditional view that the worker needs to be controlled and directed because of his inherent dislike of work) and 'Theory Y' (the idea that the majority of workers can be self-directing if they have job satisfaction and become committed to an objective)—provided managers with an insight into the characteristics of the worker.

The behavioural scientists of this period argued that work had become over-controlled and boring. They were advocating changes of the following kind:

- 'Replacement of detailed instruction by clarification of objectives.
- 'Increase of responsibility and provision of greater chance of achievement by making the job of planning, organisation, directing and controlling a joint function with employees.

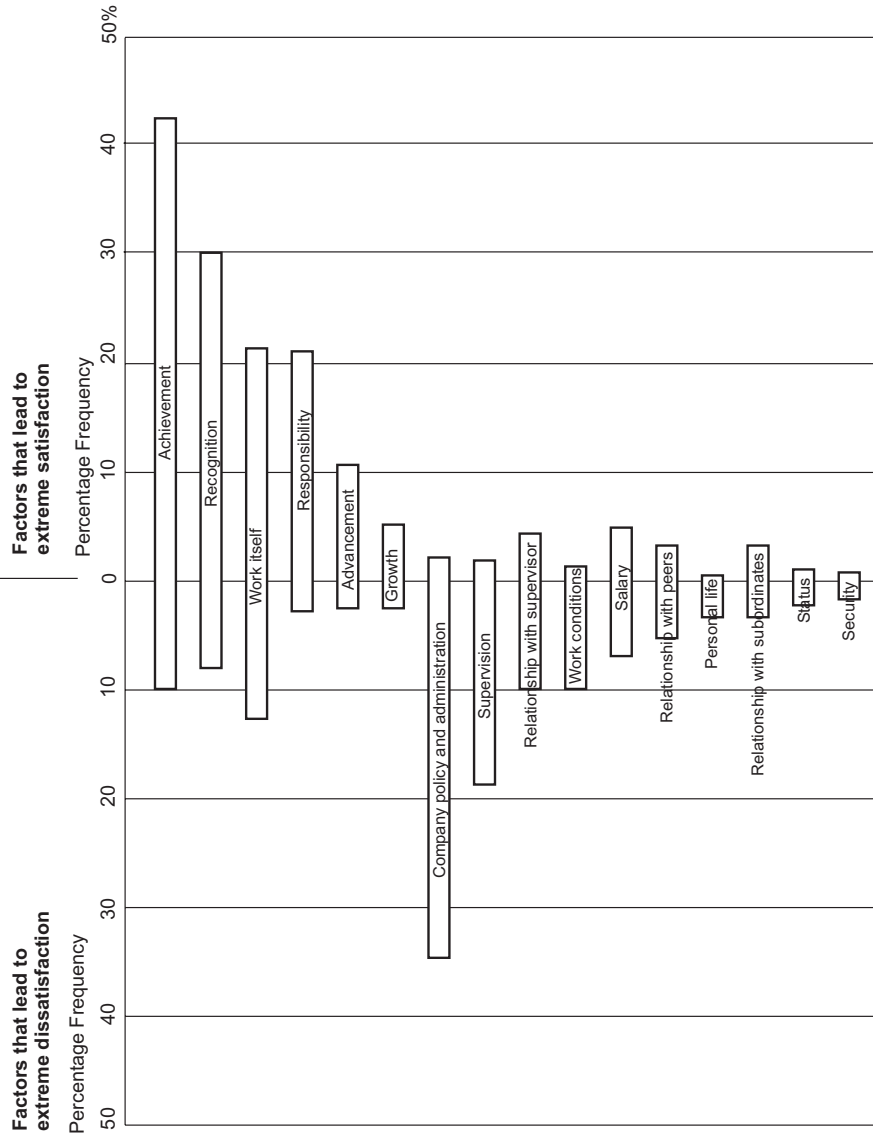


FIGURE 2-1 Factors Affecting Job Attitudes

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- ‘Study of the organisation of jobs and trying to design them so as to give greater satisfaction of human needs.
- ‘Replacement of control activities by those which seek to emphasise the manager as helper, supporter and tutor—in order to develop abilities
- ‘Setting out to build effective teams within the workforce.

During the last twenty years there have been many exercises in the application of this approach. Some of the early ones, focusing on job re-design with emphasis on autonomous small work groups, were undertaken in Scandinavia. Swedish management and unions, working together, implemented (and modified via experience) many of the ideas of job enrichment and participative management.⁵ In the UK, however, similar early exercises, in the 1970s, in participative management met with limited success, principally because the industrial environment was very different from that in Scandinavia and was not conducive to this style of management.⁶ The UK’s political and industrial environment changed in the subsequent two decades and with this came the introduction of participative management and self-empowered shop floor teams (many of the latter reflecting the Japanese concept of the autonomous operator–maintainer team). More recently, the industrial climate has changed again and brought in downsizing and contract alliances, changing yet further the style of human factors management—in a sense it has moved backwards.

Maintenance Management Behavioural Characteristics

In the previous section it has been explained that the main efforts of the human factors school have focused on identifying and understanding those elements that make an employee’s work more satisfying and therefore more effective in terms of the organisational objectives. Here, we will look at human factors from a different viewpoint. We will be concerned with identifying the main ones that influence the organisation’s efforts towards achieving its maintenance objectives. Some (e.g., a sense of ownership of equipment, affecting reliability performance) will affect the maintenance objective via output considerations, and some (e.g., motivation) via the efficiency of resource usage. It is important to understand that management can take actions to change human factors; the creation of plant-oriented teams, for example, might improve the sense of equipment ownership.

When identifying human factors the following points are helpful:

- ‘It is important to differentiate between human factors and the actions that influence them (see above).

⁵ Swedish Employers’ Confederation (Tech. Dept.), *Job reform in Sweden*, 1975.

⁶ A. V. Johnson, *Motivation of labour, staff and management*, Organisation of Maintenance, Proc. Conf. ISI, 1968.

- ‘Human factors can interact, e.g., morale affects motivation.
- ‘Some researchers consider that some human factors, such as goodwill towards the company, can be considered as dominant.
- ‘Some performance indicators provide a measure of certain human factors, e.g., the level of absenteeism is an indicator of morale.

I am not trying to be ‘academic’ about this. When auditing maintenance departments I try to get a feel for how good or bad the human factors are. There is little point in confirming that the strategy, structure and systems are good without providing corresponding information about human factors.

When seeking the key human factors in maintenance management I have found the following definition useful:

Characteristics which define the way in which an individual or group behaves or acts in an industrial setting can be called human factors. Those that influence the way the maintenance department operates are termed maintenance management human factors.

The more important of these may be divided into those that can affect individual behaviour and those that can affect the behaviour of industrial groupings of people—complete companies, manufacturing units, teams. As far as possible, industrial examples will be used to show how important these are to maintenance management.

Individual Behavioural Characteristics

Equipment Ownership: a factor which involves the degree to which a trade force and/or operators and/or the team feel *a sense of personal ownership for an equipment or an area of plant*. This is probably the most important single factor in achieving a high level of equipment reliability. Where ownership exists the equipment tends to be operated and maintained correctly.

This first became evident to me in the result of a major study of maintenance costs of fork lift trucks in the UK. Those operated and maintained by a single operator (operator–maintenance) incurred one third of the maintenance cost of pool-operated trucks in the same industry.

One of the key organisational characteristics of Total Productive Maintenance (the Japanese-developed strategic approach to maintenance management) is the move towards small, self-empowered, *plant oriented operator-maintenance teams*—of up to seven operator-maintainers with the responsibility for operating a definable sub-process or area of plant and carrying out simple maintenance tasks on it, such as lubrication, adjustment and minor servicing. The teams comprise operators (trained in superficial maintenance) and tradesmen (given operator training). The teams are also given considerable training in the way the plant operates and the relationship between the way it is maintained and operated and its failure or its inability to produce at its design level of quality. They are

encouraged, with the help of engineers, to carry out modifications to improve operation and reliability (the so called continuous improvement or *Kaizen*). All of these actions engender a considerable level of plant ownership in the individuals and in the team—they care about the equipment in the same way as if it were literally their personal property

Some of the necessary ingredients for fostering ownership were present in the FPP organisation of Chapter 1 (see Figures 1–14 and 1–15). The operators and fitters were plant oriented. However, the separation of operators and maintainers and the shift system worked against ownership. To compensate for this, individual tradesmen were made responsible for carrying out the preventive work on designated equipment—both on shifts and when they were in the weekend group.

Goodwill: ‘the state of wishing well to a person, a cause or an enterprise’ (a dictionary definition). This involves the tradesmen or operators feeling a sense of belonging with the company and wanting it to prosper. It is closely allied to ‘loyalty’ but is something more than this. The author considers it to be in many ways a key factor. When goodwill is evident at the shop floor level other problems seem to be more amenable to solution. It takes a long time to build up—perhaps many years of good relationships and trust in the management and the company. It is a function of the company treating the workforce fairly and with respect.

I recently audited an Australian underground coal mine. On a scale of 1 (= no goodwill) to 10 (= excellent relationship and trust) I would have rated goodwill as of Level 1!

Motivation: much researched and much written about, because of its importance to all industrial personnel. I consider the *behaviourist* theories (see Table 2–1) to be too general and insufficiently dynamic to describe the motivational characteristics of the shop floor. To quote from one of my earlier books:

*‘In general the industrial worker sees his job as a means of obtaining money, a lower order need, in order to satisfy elsewhere his other, higher order, needs. This view is based on the observation that people are only truly motivated when they are doing something (work, hobby, sport, home repairs) that they really want to do. Most often the worker does not experience this at work. The nature of the work is such that it is normally difficult to institute changes sufficiently to arouse true motivation.’*⁷

Applying these ideas to the maintenance tradesman is not without difficulty. To a certain extent, maintenance work has many of the ingredients needed to provide Herzberg’s idea of worker satisfaction and motivation. It has autonomy, craftsman status, pride in the quality of the work, varied and interesting job content etc.—all of this reinforced with the movement in many

⁷ A. Kelly, *Maintenance planning and control*, Butterworth-Heinemann, Oxford 1984.

companies to self empowerment. These work ingredients also emphasise how important trade force motivation is to maintenance management. Maintenance workers are among the few on the shop floor who still have considerable autonomy as regards their day-to-day actions. Thus it is difficult to check how well a preventive maintenance inspection routine has been carried out. It is also difficult to judge how well a repair has been carried out and, in some cases, whether the spares used have been the best from the company's point of view. Maintenance workers know that if they carry out inferior work the consequences of their actions take time to surface and often will be difficult to attribute to them.

In the case of the maintenance tradesman, the most realistic indicators of his level of motivation are (a) *the extent to which he knows what is wanted from him* and (b) *the level of his effort to provide it with a minimum of external control*.

When trying to influence, understand or audit motivation within a maintenance department the following aspects must be taken into consideration:

- The shop floor's industrial relations history, its present position and its deficiencies.
- The factors that influence job content and job environment.
- The external social and political environment and its influence (because this governs the extent to which internal change is possible).
- The trade force's identification with the maintenance objectives (the most important factor in their motivation).

Morale: defined in the Oxford Dictionary as—*'the mental state of an individual with regard to confidence and discipline.'* Finding a definition in a management text proved difficult; the best was *'an individual's satisfaction and confidence with membership of an organisation'*.⁸ The same work pointed out that production is not a function of morale and therefore morale is not a very meaningful concept in management thought! My own auditing experience, however, has convinced me that poor morale, whether of individuals or trade groups, most certainly affects both the quantity and the quality of maintenance work.

Morale within the maintenance department may be defined as:

an individual's perception, which may be positive or negative, of his future work prospects, and which may be induced by the success or failure of the company employing him and the ability (leadership, organisational and engineering performance) of its management.

As this implies, the negative factors affecting morale may be those that appear to threaten the individual's or group's future work security, e.g.,

⁸ H. G. Hicks and C. R. Gullett, *Management*, McGraw Hill, Singapore, 1985.

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- ‘a company’s poor economic performance;
- ‘poor company organisation and systems, inducing problems with product quality, for example;
- ‘recent workforce redundancies and the threat of more to come.

Resentment: defined in the dictionary as ‘*a strong feeling of ill will against the perpetrator of a wrong or affront.*’ The following example, drawn from one of my own auditing exercises, explains this in the context of the maintenance tradesman:

‘Hell hath no fury like a fitter scorned.’ A small power station, supplying a chemical plant, consisted of a number of large diesel generators. It was maintained by five fitters, one of them a leading hand. One of the younger (very bright) fitters had been promised promotion to supervisor level but this had not materialised—and did not ‘look like doing so. He had become resentful and obstructive (the bad apple) and this feeling had spread to two of the other, younger, fitters. They were using every IR trick in the book (bad backs, bad arms etc.) to avoid work and undermine the rest of the trade group. Weak management had allowed this situation to fester for about a year. The condition of the diesel units was deteriorating and this was likely to have a considerable effect on the overall operation of the plant.

Protectionism: can be defined in the maintenance context as ‘*resistance to sharing knowledge and information;*’ it can be affected by other human factors such as insecurity and low morale.

A typical example is provided by the technician who has built up considerable knowledge over many years about specific equipment but is reluctant to document his knowledge or convey it to other employees.

Parochialism: the dictionary definition is ‘*local narrowness of view and attitude.*’ I have encountered this in many organisations. It can occur, for example, within the manufacturing units of a decentralised organisation.

A power station, which I was auditing, provided electricity to an alumina refinery. It was set up as a semi-autonomous manufacturing unit. There was considerable narrowness of view exhibited by its manager. He was an ex-marine engineer and ran the station as if it were a ship. On each visit I felt that the gangway had to be lowered before I could go on board. The attitude of the staff was that they were set apart and different. The refinery senior management seemed to know little about the way the power station was being operated and maintained. I established that two out of the three generating units were needed at all times for full refinery operation. However they were all in poor condition and in need of major overhaul. It was difficult to take a unit out because of the unreliability of the two left in service. Before leaving the site I insisted that the refinery general manager discuss this problem with the power station manager.

Organisational design creates the boundaries between departments and it is management's job to minimise parochialism and its effects. It generates other human factor problems, e.g., polarisation (see later).

Other human factors: which I do not audit directly but are covered indirectly during the one-to-one interviews which make up the bulk of the audit programme. Some of these are as follows:

<i>Jealousy</i>	— of those on shifts exhibited by those on days, or vice versa.
<i>Attitude</i>	— a positive trade force attitude towards data collection.
<i>Envy</i>	— of those promoted.
<i>Resistance to change</i>	— to the introduction of new working methods, team working, or computer systems.
<i>Pride</i>	— in an individual's trade and in the quality of work carried out.
<i>Prejudice</i>	— a pre-conceived, biased, opinion or position on a subject, e.g., the maintenance view of production—'They break it, we mend it;' the production view of maintenance—'They don't understand our objectives we give them a line for four hours they keep it for twelve.'

Group Behavioural Characteristics

Culture: has been defined as '*the collective mental programming of people in an environment*'.⁹ It is not a characteristic of individuals, it encompasses a number of people who are conditioned by the same education and life experience. Thus, when auditing it is important to recognise and understand the culture of the country. For example, that of Saudi Arabia is very different from that of Australia and this can influence the organisation—most of the tradesmen in Saudi Arabia are expatriates.

A company can have its own culture.

A food processing plant which I audited was part of a USA multi-national that had been operating in Australia and the UK for many years. It had developed a company culture that I had observed in both of these countries, one that put a very high premium on success, hard work, fairness, tight scheduling and efficiency of thought—it could almost be 'felt.'

Further down the organisation a culture can also develop within departments.

A petrochemical complex used a functional organisational structure in which the maintenance department was large and carried out all the maintenance, even the

⁹ F. E. Kast and J. E. Rosenzweig, *Organisation and management*, McGraw Hill, Singapore, 1985.

major shutdowns. Over many years the culture within this department had developed a mix of norms, standards and behaviour weighted much more towards maintaining equipment for engineering excellence rather than achieving organisational efficiency. The department was considerably over-manned.

Esprit de corps: defined as ‘a spirit of regard for the company or group honour and interest, and for those of each member belonging to it.’ Clearly a concept of military origin and one which I observed in the major Japanese companies during visits to that country in the late 1970s. During my auditing of some fifty companies world-wide I have not come across any other companies, departments or manufacturing units which have had an *esprit* of the kind defined above. It has been suggested that one of the reasons for breaking down large functional organisations into semi-autonomous manufacturing units is to generate *esprit de corps* in each of those units (although I have not, as yet, observed this actually occurring to any extent).

Horizontal polarization: has been defined as ‘having opposite views and attitudes across departmental boundaries.’ This can best be explained via the simple model of a functional organisation shown in Figure 2–2. Conflict builds up across the boundaries of the main departments—viz. Production, Maintenance, Engineering, Stores—and to a lesser extent across the sub-departments, e.g., Electrical Maintenance and Mechanical Maintenance.

The Production–Maintenance conflict has been well documented. The maintenance view is that ‘Production built it and we mend it.’ In other words ‘they mal-operate and never let us have the equipment for proper maintenance.’ The production view is that ‘we make the money and maintenance do not understand our objectives—we give them the plant for a shift and they keep it for a day.’

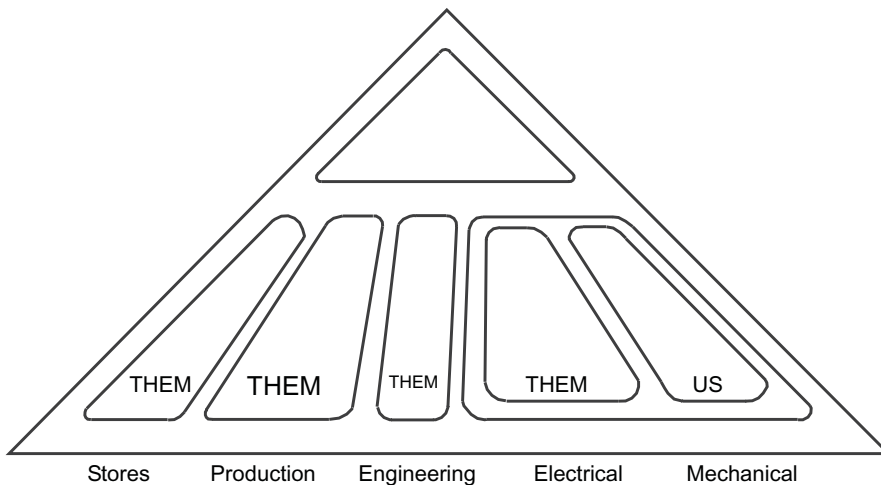


FIGURE 2–2 Horizontal Polarisation in an Administrative Structure

I was consulting on the maintenance of a paper-making machine. A production supervisor pointed out that a machine came down every three to four weeks for the replacement of a wire belt (a task of eight hours duration which the production operators carried out). When asked if this provided a window for maintenance work the supervisor replied ‘we don’t tell them when the machine is coming down otherwise we lose it for more than eight hours—we keep this information to ourselves.’

I often observe polarisation across the Maintenance-Stores interface when these functions are the responsibility of different departments. From the company point of view the spares holding objective would be to minimise the sum of the holding and stockout costs. Maintenance try to keep the inventory high, Stores Management try to keep it low—hence conflict and polarisation.

Figure 2–2 shows that the organisation can develop the ‘us and them’ syndrome across the horizontal boundaries. ‘We’ are mechanical maintenance and everybody else (including electrical maintenance) is a ‘them’—the larger the number of ‘thems’ the greater the polarisation. Once severe polarisation develops, information might flow but communication and understanding is lost.

Vertical Polarization: considerable antipathy can build up between the various levels of an organisation, especially if these are many and the organisation is large (see Figure 2–3).

The greatest degree of antipathy is often between the shop floor and the higher levels of management—a conflict in objectives and attitudes. Not only does such conflict affect communication but it also negatively affects some of the more important individual behavioural characteristics, e.g., goodwill and motivation.

The other important vertical maintenance interface is that which lies between the maintenance supervisors and their professional engineering managers. Supervisors mostly come from the trades, do not have professional engineering

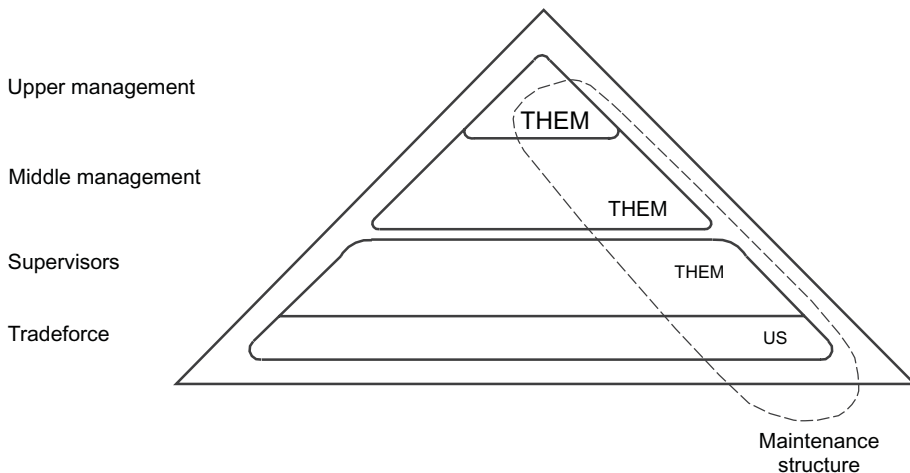


FIGURE 2–3 Vertical Polarisation in an Administrative Structure

qualifications and only rarely move into the upper reaches of management. They are, however, unique in that they constitute the only level of management that looks downwards to non-management personnel. In addition, they tend to be less mobile within the organisation than professional engineers and are the main source of trade and plant-oriented knowledge. More recently, their direct management role has been threatened by the introduction of self-empowered teams. In many industries their role has changed to that of technical advisor, planner and team leader. They have become uncertain and defensive. This has led to conflict and polarisation.

The 'us and them' syndrome (of both the vertical and horizontal varieties) is most evident in large organisations which are highly functionalised at the top, with long chains of command down to operators and maintainers. Severe polarisation in such organisations can cause complete lack of communication, organisational contraction and eventual failure.

The Effect of Outsourcing Alliances on Human Factors

So far, the discussion has been confined to a review of human factors within *traditional* organisations, those in which all the maintenance work is carried out by company-employed personnel (other than during periods of peak loading). The most recent trend in maintenance organisation, however, has been towards company-contractor *alliances* where, for example, the second-line and third-line work (and perhaps the operation of the stores) are transferred to the alliance, whose workforce combines personnel transferred from the company with new personnel brought in by the contractor. My own experience indicates that this introduces some largely negative human factors, viz.

- 'The transferred personnel suffer low morale—resenting and resisting the change, they find their position less secure. They feel that they have little in common with the contract trade force.
- 'The incoming personnel lack both process and equipment knowledge and any form of goodwill towards the company.
- 'The alliance workforce has little sense of plant or equipment ownership.

A leading contract company, when challenged with this view, argued the following case:

- 'The contract between the company and the alliance to deliver a 'level of service' is tightly specified by key performance indices. The alliance trade force is aware of this and know that if the service levels are not achieved their job-security will be jeopardised. So they are well-motivated.
- 'The contractor brings expertise in engineering and in job planning, the resulting efficiency enhancing the perception of job security and hence morale.
- 'A sense of equipment ownership is more important within the production-oriented first line teams than within the alliance workforce.

My experience of auditing human factors within alliance arrangements of this kind is, however, somewhat limited, so I present these views only for discussion. *(A fuller treatment of this topic is given in the Chapter 9 case study)*

Auditing Maintenance Management Human Factors

Human behaviour can have a profound effect on the performance of organisations. In this chapter we have been concerned with identifying and discussing those human factors that can have an influence on maintenance performance. But although they can be identified it is much more difficult to audit them objectively. Table 2–2 shows an extract from one of the several questionnaires which are used in my own maintenance audit programme, this one during one-to-one interviews with members of the maintenance trade force. It is only one relatively small part of the interviewing process. For tradesmen, questions on equipment ownership, motivation, morale and goodwill would be included in the interview plan, different sets of human factor questions being posed to the operators, supervisors, and managers. The auditor explains the question, explaining what he means by ‘ownership’ and the scale adopted for its measurement. During such interviews he also records some of the individual comments about human factors, e.g.,

- ‘We are a centralised group—we do not have a sense of equipment ownership’*
- ‘Rotation works against ownership and plant specific knowledge’*
- ‘There is no sense of ownership in the process teams, they don’t even clean’*

TABLE 2.2 Extract from a Human Factor Profiling Questionnaire

Maintenance Audit—Company Human Factor Profiling Questionnaire (Maintenance Tradesmen)							
Answer the following questions in terms of the scale below							
0	1	2	3	4	5	6	7
Do Not Know	Not At All	Very Little	A Small Amount	A Fair Amount	Quite A Lot	A Great Deal	Completely
To what extent do you feel/believe:							
1. You have a ‘sense of ownership’ for the equipment you maintain?							<input type="checkbox"/>
2. The operators have a ‘sense of ownership’ for the equipment they operate?							<input type="checkbox"/>
3. You have a ‘feeling of goodwill’ towards the company and its senior management?							<input type="checkbox"/>
4. You have a high morale?							<input type="checkbox"/>
5. You are motivated to work hard in the interests of the company?							<input type="checkbox"/>
6. Your relationship with the production operators and supervisors is good?							<input type="checkbox"/>
7. You have a good relationship with first line management?							<input type="checkbox"/>
8. You have an effective service from the stores							<input type="checkbox"/>
							Continued

A representative selection of such comments may be included in the audit report.

Auditing group behavioural characteristics requires a different approach, which is also illustrated in Table 2–2 in the case of horizontal polarisation. Question 6 is directed at determining the maintenance view of the attitudes, co-operation and communication between Production and Maintenance. Other questions (not shown) attempt to determine Production's view of the service they get from Maintenance.

When auditing large organisations I carry out surveys of opinion which include questions on human factors. Questionnaires in such cases are sent out ahead of the audit and returned during the audit period. The main aim of the human factors audit is to identify those factors which are affecting maintenance performance, either positively or negatively. When positive, advice is given on how they can be re-inforced and maintained; when negative, how they might be eliminated or their influence mitigated. For example, if, in a traditionally functioning organisation, the sense of equipment ownership is found to be poor at trade force and operator level it may be improved by the creation of *self-empowered plant oriented operator-maintainer teams*. If such a structural modification is not possible or desirable then alternative courses of action must be sought within the traditional structure, e.g., individual tradesmen made responsible for specific equipment for preventive routines. While such a structural change may improve ownership it may well affect other factors in a negative way, e.g., plant oriented teams may well increase parochialism. The point here is that organisational change requires a complex mix of structural, strategic, systems and human factors decisions. Before such decisions are taken it is essential to have as clear a picture as possible of the existing situation—an audit provides such a picture.