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GLOBAL WATCH MISSION REPORT

Manufacturing best practices and processes – a mission to the USA

SEPTEMBER 2005

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Manufacturing best practices and processes

– a mission to the USA

REPORT OF A DTI GLOBAL WATCH MISSION
SEPTEMBER 2005

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PICMET
Process Industries Centre for Manufacturing Excellence

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EXECUTIVE SUMMARY

This DTI Global Watch Mission was coordinated by the Process Industries Centre for Manufacturing Excellence (PICME), which was set up by the UK process industry to spread best practice in productivity improvement. PICME decided to focus the mission on chemicals and chemical products, one of three manufacturing areas at the heart of its work, and put together a mission team representing Huntsman Tioxide, Ineos Chlor, Innovia Films, Octel Corp and Teesside Manufacturing Centre at the University of Teesside.

The USA has a very strong chemicals sector, employs a wide range of continuous improvement practices and processes, and is facing many of the same challenges as the UK, including competition from low labour-cost manufacturing nations like China. The fact that many UK companies compete with UK-based subsidiaries of US companies, which can draw on support and new methods from their parent, confirmed the need for greater awareness of advances taking place in the USA.

The mission visited five states and six plants, engaging more than 60 people in discussions about manufacturing performance and the application of world class manufacturing methods. During visits to DuPont in Delaware, Solutia in Massachusetts, Rohm and Haas in Philadelphia, National Starch in Missouri and Arch Chemicals in New York, and Manufacturing Extension Partnership Management Services, the mission team gained first-hand knowledge of the use of tools and techniques such as Kaizen, total quality management and just in time manufacturing.

In particular, the mission investigated the strategies and business drivers behind the application of these techniques, and their achievements. It also explored people management and support function issues. The USA is not using different tools and techniques to the UK, but in some cases their application is exceptionally good, even though there is limited shop floor involvement in improvement programmes. It is reassuring to know that the UK is already aware of the best ways of effecting improvement. The priority is that UK companies remain focused and consistent in their application.

Exhibit E.1

Mission team; L to R: Paul Ellwood, Wayne Harkins (Divisional Director, National Starch), Paul Daniels, Allan Cowan, John Forrest, Sarah Redfern, Tom Furdek (Plant Manager, National Starch), Munir Ahmad, Mark Lewis.

INTRODUCTION

UK performance

During the development of thinking on applying the ideas of continuous improvement in the UK process sector in the early 90s it was identified that benchmarking of manufacturing performance was a powerful method for seeing where improvement could be made most profitably.

Work by Prof Roger Benson and Prof Munir Ahmad set out the basics of an approach for the process industry and this was further developed by the Process Industries Centre for Manufacturing Excellence (PICME) in the shape of a national benchmark scheme in 2001 and subsequent years. PICME itself was set up by industry sector trade bodies with the DTI in 2000 to collect and disseminate best practice in process manufacture.

This led naturally to a desire to see how UK process plants compared with those in other parts of the world. Again some comparisons with Europe were done using basic benchmark data and the EU-supported Max-Serv project provided further data on this.

The evidence indicated that UK plants were no better than the equivalent elsewhere and in some crucial areas were worse.

Some clues were needed as to what the best operations do. Comparisons in the UK were useful but the industry is increasingly spread across the world and competition comes from everywhere.

Many in the UK industry felt that US practice in process manufacture might well be more advanced given the prominence of US-based multinational companies. In addition, many of the popular improvement initiatives so far seen had originated in the USA, and the track record of companies such as DuPont in the related area of safety is impressive.

PICME, with the support of the CIA Manufacturing Network and the DTI Global Watch Service, organised this exchange of best practice visit with a range of leading US companies.

KPI	UK Plants	European Plants	World Class
Customer on time in full (OTIF %)	93.1	93.1	99.7
Supplier on time in full (%)	87.7	86.0	99.7
Customer complaints (%)	3.1	2.2	<0.001
Overall equipment efficiency (OEE %)	71.3	76.8	98.2
Capacity used for changeovers (%)	11.3	8.4	0.5
Reportable accidents per 100,000 hours	10.9	7.4	0.016
Finished goods days of cover	16	21.2	2
Raw materials days of cover	33.9	28.3	4
Training days per year	3.4	2.7	>14
Absenteeism (%)	2.1	2.4	<1

Exhibit I.1 *Typical performance in UK process industries*

The host companies were:

National Starch, Kansas City plant
Arch Chemicals
Solutia
DuPont Kalrez and Vespel
Rohm and Haas

The mission team also met the Manufacturing Extension Partnership National Productivity Program and attended the Synthetic Organic Chemical Manufacturers Association (SOCMA) conference in Philadelphia.

The mission team representing leading manufacturers included:

John Forrest *Huntsman Tioxide*
Paul Daniels *Ineos Chlor*
Paul Ellwood *Octel Corp*
Alan Cowan *Innovia Films*

The team also included leading academic Prof Munir Ahmad, and Mark Lewis and Sarah Redfern of PICME.

The delegation visited five states, travelled 9,272 miles, toured six plants and engaged over 60 people.

Form of mission

The mission concentrated on visiting leading process manufacturers which had been identified through industry contacts and by reputation.

Each visit included a factory tour and discussion on manufacturing improvement approaches with the management team at the site. In two cases (DuPont, Rohm and Haas) the mission team met with the corporate manufacturing excellence group at the same time.

Coverage of the industry was wide ranging, from commodity chemical production (National Starch) to speciality chemicals (Arch, Rohm and Haas) with plastic film (Solutia) and rubber/plastic components (DuPont).

The mission team also met a cross-section of the US specialised organic chemical industry and finished with discussions with the US manufacturing improvement programme equivalent to PICME.

Mission objectives

- To promote greater awareness of advances taking place in manufacturing best practice through direct contact with key US organisations
- To gain a better insight into the application of world-class manufacturing methods ie Kaizen, total productive maintenance (TPM), total quality management (TQM), just in time (JIT) within the sector, and of any new programmes which may be under development
- To improve the flow and quality of information into UK companies regarding management best practice, technology and innovation from US industry
- To share the lessons learnt throughout organisations within the UK process sector and support UK manufacturing professionals in building a best practice network (the PICME Club) for further missions
- To establish links with industry and academic centres of excellence in the USA to encourage change through innovation

1 BENCHMARKING IN THE PROCESS INDUSTRIES

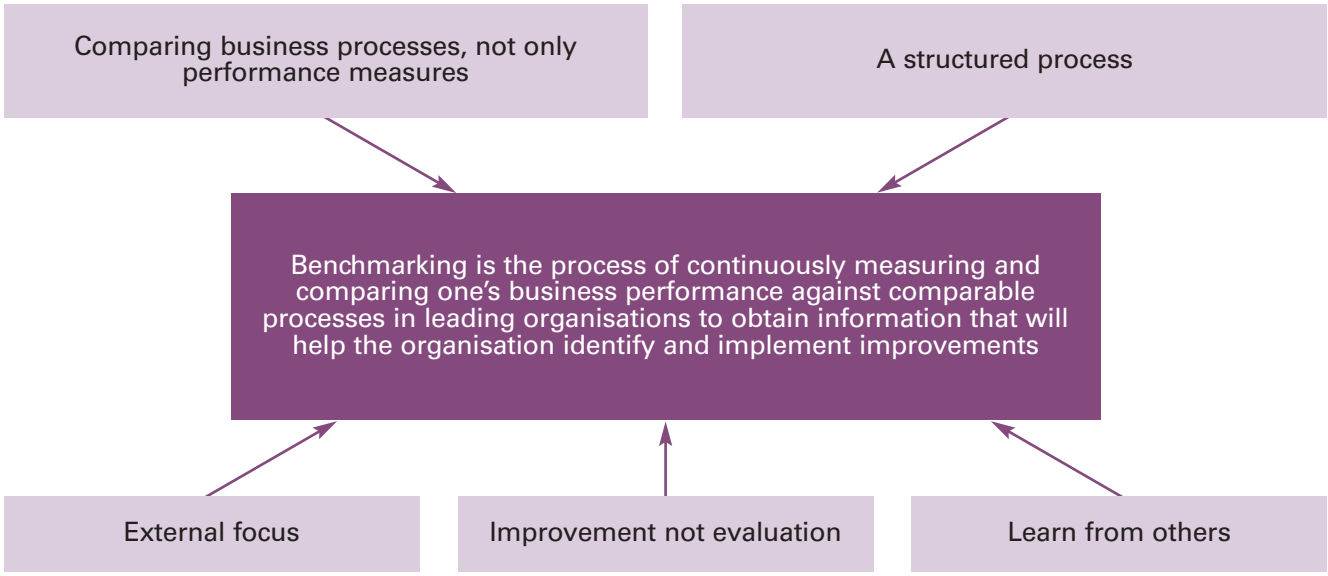

Exhibit 1.1 *The definition of benchmarking*

Introduction

Benchmarking is a structured process comparing the performance of similar manufacturing assets against the best in the world, with the intention of learning and hence continuously improving.

World-class manufacturers are continuously benchmarking their performance. They are placed at the top of their industries as a result of their consistent delivery of superior performance. This superior performance is achieved by the continual assessment and improvement of business processes, the application of the proven best solutions to improve the performance of key business areas, and a continual measurement of financial and operational performances. Exhibit 1.2 shows the relation between application of best manufacturing practices and the ability to achieve superior performance.

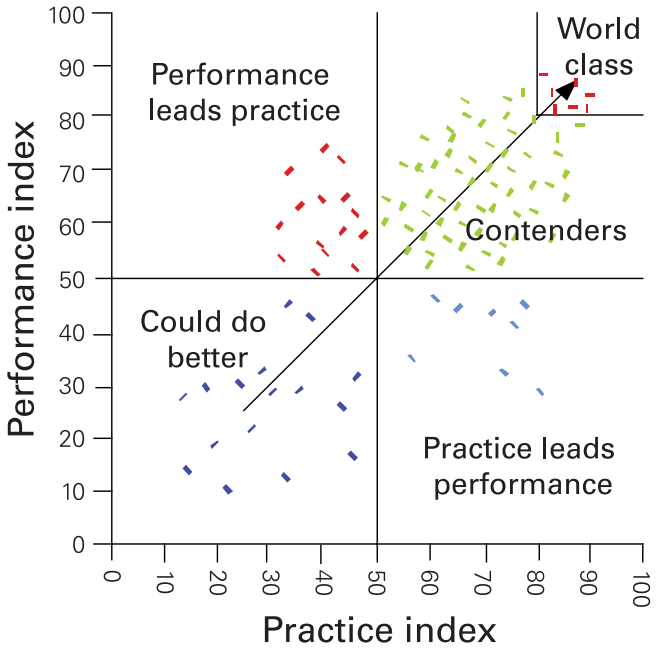

Exhibit 1.2 *Performance/practice plot*

Generally, there are four types of benchmarking:

- Internal benchmarking – applies more to large organisations that have various business units. It is about comparing internal operations from one sister company to another.

- Competitive benchmarking – specifically compares competitor to competitor, using the product or function of interest. This goes beyond the traditional product or service engineering, but it is important to learn and understand about competitors' methods, their processes, innovation, strategies, markets, etc.

- Functional benchmarking – is the comparison of similar functions within the same broad industry, using wide industry leaders as partners.

- Generic benchmarking – involves establishing the comparison of business functions or processes that are the same, regardless of type of industry. Generic benchmarking is a long-term challenge and reflects a total change in the culture. It is usually found in learning organisations.

The fact that the process plants are less familiar with measuring and benchmarking their own process manufacturing performance has been discussed in recent literature. The argument often used as to why this unfamiliarity occurs is that the process industries are different. Therefore the implication is that performance measurement and benchmarking techniques do not apply. These techniques, however, have been developed and successfully applied in other manufacturing industries such as electronics, retail and automotive.

In the book *Benchmarking in the Process Industries (published by the Institution of Chemical Engineers ©1999 Munir Ahmad and Roger Benson)* a methodology is introduced which comprises a set of effective performance measures, benchmarking data, a procedure for defining performance gaps, selection and implementation of improvement practices. Brief descriptions of these fundamental areas follows:

Measuring performance of the process plants

The following measures are proposed for use in benchmarking the process plants:

Customer services
- On time in full (OTIF)
- Customer complaints
- Due date reliability
- Adherence to production plan
- Stock turn

Reliable assets
- Product rate
- Quality rate
- Availability

Operational excellence
- Statistical process control
- Manufacturing velocity

Motivated people
- Absenteeism
- Training days
- Staff turn-over

Safety, health and environment
- Annual reportable injury accidents
- Environmental performance

It is recommended to use fewer focused measures to make the process more effective. As a guideline, the total number of measures should be fewer than 15.

No.	Key performance indicator	World-class performance
1	Adherence to production plan	> 99%
2	Overall equipment effectiveness (OEE)	> 95% for continuous plants > 85% for batch plants
3	Process capability (CpK)	> 2
4	On time in full (OTIF)	> 99.7%
5	Stock turn	> 25
6	Value added per manufacturing employee	£400K
7	Training days per employee	14 days
8	Absenteeism	< 1%

Exhibit 1.3 *World-class performance of process plants*

Benchmarking data

The sources of appropriate benchmarking targets for the various measures for world class performance were also identified.

The benchmarking targets are readily available once the framework has been agreed upon. They are derived from the literature, the contacts with customers, contacts with suppliers, and personal experience from working and operating process plants.
The performance of world class plants is an absolute concept which represents what is the best performance or practice anywhere in the world.

It is quite common in the process industries to determine during the first benchmarking exercise that:

- The hidden plant may well be in excess of 30% of output
- Stocks may be reduced by 50%
- The fixed cost can be reduced by anything up to 20%
- Potential variable cost reduction by further 10%
- Customer service is poor

Given that they may often be achieved with minimal to zero capital expenditure, and are delivered through the people of the plant itself, they provide very interesting opportunities.

Variable cost gap = (actual variable cost – world class variable cost) x output

Fixed cost gap = actual fixed cost – world class fixed cost

$$\text{Stock saving gap} = \frac{1}{\text{actual stock turn}} - \frac{1}{\text{world class stock turn}}$$

$$\text{Hidden plant} = \text{output} \times \left(\frac{\text{world class OEE}}{\text{actual OEE}} - 1 \right)$$

Exhibit 1.4 *Calculations used to define performance gaps in the process manufacturing plants*

Through benchmarking, gaps were identified and an outline of the procedure to quantify existing gaps was provided. This included added value per employee; hidden plant; variable cost opportunity; fixed cost per tonne; maintenance cost; potential cost savings opportunity; and safety, health and the environment (SHE). All the tools provided by the methodology of benchmarking within the process plants focus on quantifying a financial gap; this sets out the priorities and justifies the case for continuous improvement.

After identifying the gaps, guidelines were derived for companies on how to introduce process improvements which are realistic and achievable.

Signposting the route to process improvement

The first task for the person undertaking the benchmarking is to use their experience and mature judgement of improvement processes, plus their knowledge of the plant, to determine what is practically achievable in the future and what the priorities are for that particular plant. For example, while the hidden plant may represent the largest financial opportunity, the plant operates in a low-cost restricted market so the focus will be to reduce the costs. Profs Ahmad and Benson (1999) have provided a chapter in which they have defined a road map to identify the selection process of most appropriate technique to make the improvements. They have recommended the improvement focus to be in the areas of: hidden plants, availability, product rate, quality rate, supplier quality, process control, process trips, variable costs, fixed costs, supply chain (stock turn), raw material supply, organisational effectiveness and regulatory compliance.

Profs Ahmad and Benson (1999) have also identified: Kanban, Taguchi, Cedac, Kaizen, pinch technology, JIT, TPM, statistical process control (SPC), business process reengineering (BPR), failure mode and effect analysis (FMEA), single minutes exchange of dies (SMED), poke yoke, agile manufacturing, flexible automation and intelligent manufacturing as some of the most appropriate tools to improve manufacturing performance.

2 MANUFACTURING STRATEGY

Aims

The purpose of this section is to understand how the sites visited approached the development and deployment of a manufacturing strategy. It also examines the key themes that were contained within the strategies presented.

Introduction

All the sites visited had a manufacturing strategy in one form or another. The mission was clearly interested in deriving any learning from how the companies approached the subject. To this end the team examined how each strategy stood up against the following criteria:

- Ensuring alignment of manufacturing with business objectives
- Identifying the critical manufacturing performance issues for the business
- Establishing ownership and accountability for improvement

As one might expect, the team did witness some significant variation in approach to this subject but also some common themes. These are discussed in the form of the learning points below.

Learning points

The effective communication of business strategy and performance is a priority. All the sites visited put an emphasis on quality communication of business performance. In all cases this was off-the-job verbal communication. On some sites the management team held set-piece events that involved the whole workforce at the one event and clearly necessitated the closure of the plant for the day. On others with continuous processes time was created outside the shift pattern and supported via overtime.

How effective the organisations were at converting this awareness into true ownership for the delivery of improvement varied quite considerably. At one extreme one company had a very robust policy deployment cascading corporate objectives through to individual objectives for all employees. Linked to this all employees were involved in a company and individual performance-related bonus scheme. At the other extreme some companies were not holding annual reviews for 'hourly' staff and thus had no mechanism to set improvement objectives for the majority of their employees. All such companies recognised this as a significant weakness but cited the position of unions as a barrier to implementing an appraisal system.

The focus on the customer is stronger than in the UK. As would be expected in the process industry all the sites visited had SHE as a major priority in all their activities. The other common theme was that all the companies had translated the need to be customer focused into their manufacturing strategies. Their key performance indicators (KPIs) reflected this position with a heavy focus on delivery performance. We also saw many examples of this focus out on the plants with 'Days since last customer complaint' KPIs very visibly displayed and 'The next inspector is our customer' painted on despatch roller doors being two examples.

Companies with a manufacturing excellence (MEx) programme had the most clearly defined and comprehensive manufacturing strategies. Three of the companies visited had adopted a traditional MEx methodology. This is based on a defined set of elements that cumulatively define MEx and a matching set of essential practices needed to achieve it. In the relatively brief time the mission team had at each facility these were the companies which were best able to demonstrate that they had robust manufacturing strategies in line with business requirements.

In common, these three companies were able to define what the critical manufacturing performance issues were for their business and how they currently compared to a benchmark of some sort. This enabled them to generate a performance or 'value' gap that in turn was a focus for their improvement plans. The benchmarks were quite often internal, based on other sites in the group, but were easily validated and relevant.

Another common factor with these three companies was the practice of continuous measurement of fundamental manufacturing KPIs such as overall equipment effectiveness (OEE) linked to regular reviews of maximum proven rate (MPR). They also appeared very keen to understand exactly where they were on a particular strategic journey. One company had developed an excellent waste-free manufacturing evaluation system. This was clearly based on Lean Principles, but had been adapted to suit their needs; Lean had too many head count reduction connotations.

Within these companies the most effective deployment of the methodology was in an organisation where manufacturing was owned at board level. Another company that actually had a more impressive MEx system, but in which manufacturing responded to business units, had only to date achieved a 50% deployment.

At the remaining sites the manufacturing strategy was less clear and there appeared to be an overlap or confusion between the strategy and the improvement programme. In one case it seemed that the deployment of the improvement programme (a Six Sigma and Lean combination) was actually the strategy. The amount of energy behind the programme and the degree of employee involvement was admirable. However, one could be concerned that in an environment where fundamental manufacturing measures such as OEE were not in place, the effort was not being deployed in an optimum way.

The other factor that linked the latter companies was that their strategies didn't clearly articulate where they wanted to get to by when eg cost per tonne of x by 2008, volume of y kilotonnes by 2009, etc. Success seemed to be measured in savings delivered by projects rather than the delivery of a particular business critical strategic objective.

3 BUSINESS DRIVERS AND METRICS

Aims

The purpose of this section is to understand the role played by KPIs in the MEx initiatives that were observed.

The different types of performance indicator that are in place at the sites will be discussed in detail along with the common themes that emerged regarding their use in driving performance.

Introduction

KPIs were used at all the sites visited and were an integral part of efforts to improve manufacturing performance. Even though the character of the MEx programmes varied significantly (as did the formal organisational relationship between manufacturing, the businesses and the corporate body), a number of general learning points emerged. This account is structured around these learning points.

Learning points

A clear connection is made between the desired business outcome and manufacturing KPIs. Systems were in place at all plants to ensure that the business strategy was translated into associated goals for the manufacturing assets. Where possible such goals were quantified and thus became the key performance indicators. The same KPIs were invariably cascaded to become the personal targets of a management-by-objectives system.

KPIs are grouped by theme and the same themes recurred at all sites. The two themes with highest priority were always the same: No.1 was safety, health and environment, No. 2 was delivery performance. Thereafter, there was no clear hierarchy but the common themes were:

- Quality
- Asset productivity
- Maintenance
- Personnel
- Supply-chain metrics
- Financial
- New product development

The most effective use of KPIs involved the creation of a 'balanced scorecard' of metrics which were intended to cover all aspects of the manufacturing challenge. In some instances a small number (four or five) of headline KPIs were used to communicate progress to the wider business and stakeholders.

SHE KPIs

The most common headline indicator was the amount of time since the last lost time accident (LTA) or reportable injury. This was supplemented by a variety of other indicators such as:

- Individual SHE meeting attendance
- Results of safety audits
- Incidents last month
- Housekeeping results
- First aid cases
- Near misses
- Loss of containment figures
- Results of behavioural safety assessments

The tracking of individuals' attendance at safety meetings was a practice repeated at a number of locations. At one site, the

standard was set unequivocally at 100% and failure to attend resulted in the individual's site swipe pass being erased. In principle any individual suffering this fate would have to speak with the site director to have his pass re-instated, but to date no-one had fallen foul of this rule.

It was very common to see the application of the 5Cs Lean Manufacturing technique as a means of ensuring a safe workplace environment. Indicators relating to the maintenance of the improved environments were used to drive the behaviours associated with the 5th C (customise and practice).

A commonly held belief was that achievement of SHE excellence was a pre-requisite to achieving MEx. At the extreme, one company believed that MEx would follow SHE excellence without the need for a specific technique-related programme (eg Six Sigma or Lean). They felt that the behaviours associated with best-in-class SHE performance would, without further prompting, lead their people to seek opportunities to improve manufacturing productivity.

Delivery performance KPIs

The OTIF metric was used at all sites, with each of them being careful to define the reference point: Was it performance relative to customer request or their commitment following that initial request? The most rigorous metric was clearly felt to relate to the customer's request.

Other customer-related metrics included:

- Shipments on time
- Customer complaints

The importance of this metric (second only to SHE) suggested a greater emphasis in the USA on customer service than in the UK.

Miscellaneous metrics

Examples of other KPI themes and specific metrics are shown in Exhibit 3.1.

The effective communication of KPIs is made a priority. One company has created a number of 'point teams' to oversee the communication of KPIs. Each team was assigned a particular theme (safety, quality, customers, manufacturing, people, financial, personnel) and had its own team charter and accountability. The KPIs were presented on a series of boards (one for each theme) on the main corridor at the entrance to the plant.

Another good practice was to hand over responsibility for the maintenance of KPI boards to improvement teams themselves. This resulted in the establishment of SQCD (safety, quality, cost, delivery) boards directly at the work area. And by handing over responsibility to operators to populate the KPI boards, metrics were taken much further than management alone could have accomplished. One example showed the results of workers' auditing of colleagues performance. Such audits were analogous to behavioural safety audits but related to conformance to standard tasks.

Another site presented its headline KPIs (LTAs, on time shipments, quality right first time and OEE) in the main meeting room as well as the labs and control rooms. The quarterly results for these KPIs were also available on a huge display board at the main factory gate. They used other specific metrics that had meaning on a local plant or project level (eg yield, press rate, wash water reduction, safety observation statistics), but these four headline metrics were clearly considered to give a balanced view of performance.

Most sites operated a system of morning production meetings at which KPIs were used to assess the previous 24 hours operation.

Theme	Metric
Quality	Audit scores
	Days without a complaint
	Year on year comparison
	Monthly scrap
	Right first time
	No. of overdue corrective actions
	No. of open corrective actions
	No. of repeat actions
	No. of waivers and amount of product waivered
	No. of customer complaints
	Internal rework (lost time to change process to meet customer needs)
	External rework (quality failures)
	CpK
Asset productivity	Daily volume targets
	Asset utilisation
	OEE
	Uptime
	Production capability
	Average set-up time
	Flow time
Maintenance	Priority 1 preventative maintenances (PMs) completed on time
	Press maintenance
People	Absenteeism
	Overtime (%)
	Average no. of suggestions made
	Results of employee surveys
Supply chain	Campaign deviations
	Adherence to schedule
	Stock turn
	Supply-chain cycle-time
	Time from order to in stock
	Days stock holding
Financial	Yield
	Previous week overtime
	Cash-to-cash (days)
	Bonus
	Disability bonus
	Opinion survey
	Communications meeting attendance
New products	Number of quotes
	Time to prototype
	Flow time

Exhibit 3.1 *Examples of other KPI themes and specific metrics*

Use of Pareto analysis to prioritise downtime issues was common. All sites gave the whole workforce comprehensive briefings on a quarterly basis. Such briefings would often involve halting production for a period of time, and their subject-matter was SHE, business and manufacturing importance. KPIs were used extensively at such briefings and to provide continuity of communication between briefing sessions.

External benchmarking with industry standards is not common. Benchmarking was not a common practice at the sites visited, although managers in their associated corporate bodies had extensively benchmarked practices and performance. Where benchmarking does take place then it is between sister sites in the same company. To this end, a number of companies had established global forums to discuss and share both good practices and performance standards. These forums varied between those that covered manufacturing in general and those that concentrated on a particular topic, eg OEE. Typically these forums involved e-mail communication, a quarterly conference call and an annual residential seminar.

At one site the individual metrics within each KPI theme were given a weighting to characterise their relative importance. This weighting was multiplied by the actual performance to give a percentage score. These were averaged to give an overall score for each theme. This process (including the weighting) was the subject of an internal calibration check between different sites in the company.

KPIs evolve over time and change in line with the progress along the improvement 'journey'. A number of companies had made significant progress in their improvement plans, and had realised that the metrics chosen at the outset were no longer relevant to current challenges. An example of this change in metrics with the phase of the improvement project with respect to plant reliability is illustrated in Exhibit 3.2.

Where used, statistical process control (SPC) systems were completed manually rather than as part of a software package. At a couple of sites analytical parameters and cycle-time were monitored using SPC. In each case the plotting of new data points was done manually rather than as part of some automatic software system. If a new data point required action then operators would make use of troubleshooting guides that they had helped to formulate.

OEE is not as widely used as in UK. Within the UK process industries, OEE is becoming the measure of manufacturing performance, and yet it was only used at 50% of the factories in this study. While this was acknowledged as a shortcoming at some companies, it is also a reflection of the greater emphasis placed on delivery performance as the dominant (other than SHE) manufacturing KPI.

Phase of reliability improvement	Metrics
Bad actor control	Mean time between failures
	% emergency work
	Cost
Work efficiency	% overtime
	% preventative maintenance
Planning and scheduling	% planned work
	Hours per work order
Operational excellence	Continuous improvement

Exhibit 3.2 *Change in metrics with the phase of the improvement project with respect to plant reliability*

4 WORLD CLASS MANUFACTURING

Introduction

This section of the report looks at how the industry is performing against what is considered to be world class manufacturing (WCM) performance, the use of continuous improvement tools and the delivered evidence of success. This section is split into two, one discussing results achieved from a pre-designed questionnaire sheet, and the other looking at observations made during the plant visits which were carried out on all manufacturing sites

Assessment process

In order to judge WCM performance the assessment process was based on 13 questions in the full assessment pack as well as 28 categories for plant observations.

Each of these questions was scored from 0-100% based on the level of commitment and application. As mentioned previously the results were then taken from each delegate and pulled together into a single set of results which are commented on below.

Number	Question	Average (%)
1	Has a detailed analysis of the maximum potential for improvement of the current assets been carried out based on best demonstrated world class performance?	58
2	Is the gap analysis used to drive the improvement plan priorities of the plant/functional teams within the manufacturing unit?	58
3	Is there a documented improvement plan for the unit and/or for each plant/functional team? Does the plan have prioritised actions, action owners, resources allocated and timeline defined?	66
4	Is there a system for project managing the improvement plans that has been defined and therefore tracking delivery of performance improvement?	69
5	Is there evidence of knowledge, training and use of manufacturing systems techniques eg brainstorming, SMED, Kanban, visible factory, root cause analysis (RCA)?	59
6	Are people from all levels in the organisation formally involved in improvement activities?	50
7	Do you have a system for handling customer complaints? Does the system effectively reduce the complaints through time by driving improvements in manufacturing operations, product fitness for purpose and customer service?	58
8	Do you have written standard operating instructions which cover all aspects of operation ie raw materials prep – equipment set up – process start up – normal process operation – process changes – process shutdown – emergencies – safety routines?	65
9	Do you have a clearly documented set of target operating conditions and allowable limits for all relevant process parameters?	71
10	Do you measure the variability of the parameters affecting the key metrics? Are they under control for all process states (ie start-up, shutdown, normal operation, rate change)?	61
11	Are measurement techniques in place to detect promptly a shift of pre-determined size from the target value for all key parameters? Are procedures in place to ensure the accuracy of measurement of all key parameters?	56
12	Do you balance supply, demand and inventory effectively?	58
13	Do you have effective decision processes to resolve cross-functional supply chain issues?	56

Exhibit 4.1 *World class manufacturing – overall results*

Gap analysis/benchmarking

At none of the companies visited was there any evidence of benchmarking outside of their own company boundaries. In this section the best witnessed areas involved internal benchmarking against different production sites, but the more common practice was certainly more site focused. Although recognised as a weakness with several senior managers only two companies were making any attempts to obtain relevant benchmark data. Although it can be argued that benchmarking can be overrated, especially when processes become more individualised, there is no doubt it has a valuable role to play when considering charting one's own improvement rate and performance. In many respects the evidence is that the UK industry as a whole is much better aligned for providing the frameworks to capture data for direct comparisons.

Gap analysis used to drive improvement

Two of the five companies had clear links from their improvement plans back to the gap analysis. The best examples appeared where clear, strong, committed leadership exists that was consistent with the drive and support for the continuous improvement programme. Again approaches varied, from a central organisation group which carried out very detailed gap analysis and provided skilled resource to lead improvement programmes, to individual sites that carried out their own comparisons and improvement programmes. The first method brings a more skilled and common approach to an organisation (however, this is only done by an invitation of a business unit manger and is not compulsory) whereas the second approach has much better ownership and long-term sustainability that can adapt more to the local culture.

Project management of the improvement plan

In this area all plants were strong. Once a decision had been made to run a project, a leader was appointed and timescales and resource set. Some adopted more formal approaches using sponsors and tools, for example Six Sigma, whereas others adopted KPIs. On the whole the standard was high and reflected practice that had been well-established in manufacturing for several years. The best example witnessed was where departmental managers were assigned specific improvement tools, ie a 5C champion, a SMED champion, a Visual Management champion, a TPM Champion, and a Continuous Flow champion.

System for tracking improvement plans

Tracking improvement plans can take on several different formats, from an individual manager who has responsibility for the programme and monitoring via individual project reviews, to formal group sessions with project leaders going through their individual KPIs. Regardless of the system imposed strong senior leadership is important – they need to be consistent and very supportive. If these fundamentals are there the necessary results will be achieved.

Evidence of knowledge, training and use of manufacturing systems

All the companies visited had set up some form of internal training/knowledge transfer. Some systems were quite complex, involving brainstorming, use of electronic tools, a high percentage of multi-skilled staff who were trained in four or more jobs, and shop floor operators who were involved in the recruitment process. However, there was little evidence of this type of training adding value to the organisation and therefore the question can be asked whether it was training for the sake of training. This is a

fundamental consideration with any shop floor training. Where success could be shown was in the practical application of simple tools involving all levels of an organisation. 5C/5S and visual management is ideal for this and very quickly engages a large proportion of an organisation with immediate results around morale and plant efficiencies.

Are people from all levels of an organisation involved?

As mentioned above, the start of any programme is critical and engaging as many key people as possible at the beginning will govern the level of success and penetration into an organisation. With this in mind the best companies are starting with some of the fundamentals ie 5C/5S for workplace organisation and introduction of visual management. This has achieved the desired effect in terms of motivation and engagement. Other areas where companies have missed out on an opportunity are with respect to data entry/collection. New tools have been brought into place to monitor asset utilisation and create an accurate source of data for monitoring and targeting the improvement programme, but instead of the operators who are actually working on the line taking ownership of the data entry, it is carried out by engineers or in some cases shift supervisors. This is a missed opportunity, especially as there was little evidence of the results being displayed back on the shop floor. This creates the perception that this is only a management tool with no or little operator impact.

Systems for handling customer complaints

There was little factual information with regards to handling customer complaints. Again this needs to be put into context as it can be a difficult subject to discuss openly. Traditionally companies guard this information very closely and there was evidence that information had been removed from notice boards prior to the team's plant tour. In their defence, customer focus was certainly evident and through informal discussions during the tours clear end-use application knowledge was present, as well as a realisation of the problems they could face. The only graphs that were present would suggest at customer complaint rate of around 4% of sales turnover – which would be considered to be high.

Standard operating procedures (SOPs)

All the plants used standard operating procedures. Novel features in this area included operators carrying out audits to check their own colleagues' compliance and shop-floor operators writing the operating procedures. Where further improvements could be made was in the location of the SOPs. They were very much hidden away in a folder in the office. A much better approach would have been localised displays. Surprisingly there was very little discussion on this topic, which put into question the value each organisation put on them.

Target operating conditions

As has been mentioned previously, there was good use of computers and mimic boards in all shop floor control rooms that were visited. This included built-in alarm packages with high and low deviation limits set for key parameters. Again accessibility is slightly under question; at one plant the operator knew of their existence but was not sure how to access them. In general the standard was high.

Measuring the variability of key parameters

The age of the plant mainly determined the technology that was used in this area. Control room mimic boards were very evident with key parameters on display and there was also mention of the use of SPC charts – however,

these seemed to be restricted to quality-testing parameters. For WCM one would expect to see more at-point-of-use monitoring and charting of performance. Along with looking for standard operating conditions, it was disappointing that they were not more evident.

Shift in target values for key parameters

As above, this was mainly dependent on the age of the plant visited. There was wide use of alarm packages, presumably using key parameters. However, it was a little concerning that none of the tour guides or office discussions focused on this point, which brings into question the perceived value to the organisations. This was particularly the case at one plant where an alarm was ignored for at least 10 minutes while the team was passing through.

Balance supply, demand and inventory

None of the companies visited appeared to have a good balance of stocks. The average stock turn would appear to be around four, with the best around 12. Discussions were held with regards to a progressive scheduling system starting with a 90-day schedule and moving towards a two-week plan that becomes fixed three days prior to manufacture. There was one area where an application of a kanban system was discussed during a visit. In this case the plant in question was using it to control work in progress through three production cells. There was good use of visual management and also good understanding from the shop-floor personnel involved. Although there was general recognition of scope for improvement in all the plants visited, there was little evidence that any work had started apart from the one example of the kanban system.

Decision process to resolve cross-functional issues

There was no obvious system discussed at any of the facilities other than one where the decision is pushed upwards until it reaches a senior enough level for someone to take the decision for the cross-functional team. The areas where this appears to work successfully does not cause long-term damage because strong leadership is on-hand to smooth issues through.

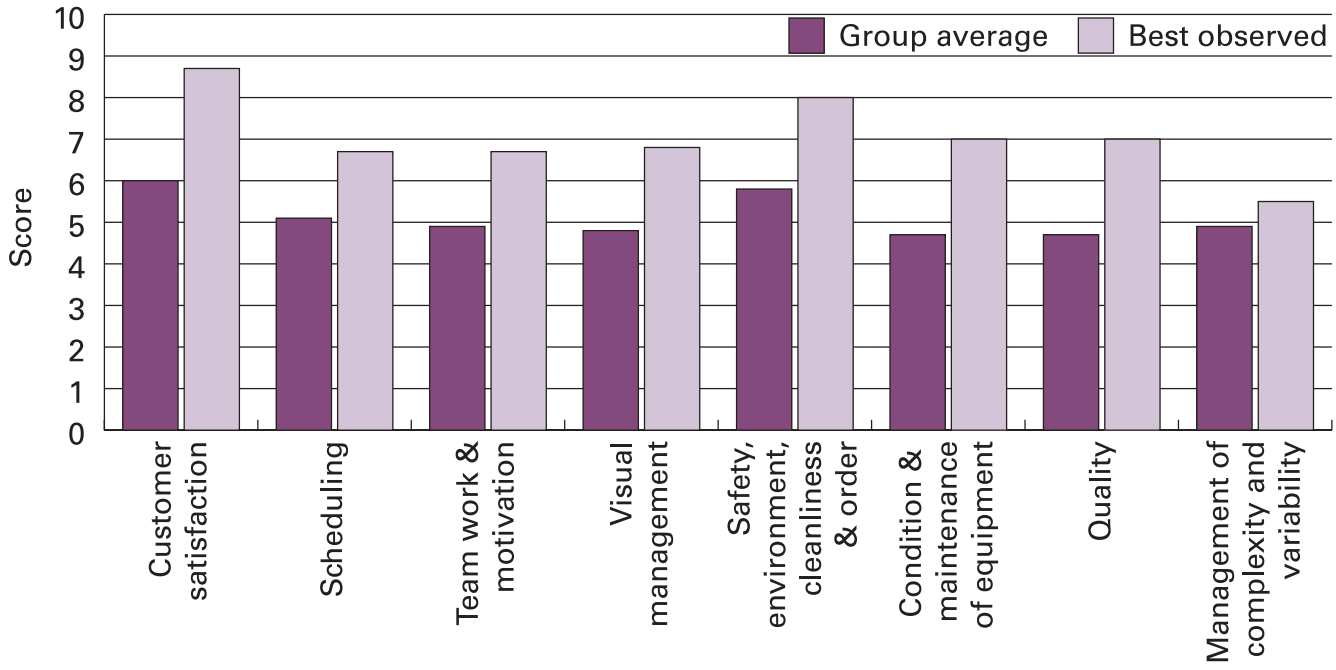

Exhibit 4.2 *Plant observations*

The plant observations back up the questionnaires that were completed, ie the US manufacturing industry is on a par with the equivalent UK sector. If anything the UK has a head start, with government-funded organisations being successful in transferring good practice tools across the different manufacturing boundaries. In the USA it is only really getting started in the chemical sector and may still suffer from looking inward too much rather than looking for new, better methods outside their own operations.

Where good practice was demonstrated it was carried out with great vigour and commitment, and this was evident on the plant tour. There was good application of 5C/5S supported with fact sheets and notice boards explaining the concept and what it meant to individuals. There was also good use of visual management to highlight the expected standard to be maintained, tools boards not only for operators to carry out repairs/adjustments but also local tool cupboards for maintenance staff to carry out repairs or large-scale product changeovers. The visual impact of a well-organised plant – from the initial impact of entering the gate and being faced with a 4 m^2 KPI board to walking around the shop floor and seeing clean and well-maintained equipment, with the staff having real pride in the standard they are maintaining – is inspiring. It immediately creates confidence in the people and in the product they are manufacturing and would give suppliers a sense of confidence that they were buying a good product from a well-managed company. Further confidence is gained from the obvious involvement that is happening at all levels within the organisation. This was also evident on a unionised site where, unlike all the other plants visited, this was not seen as an obstacle but more of a reason to engage and involve everyone.

In other cases there were very much mixed signals – good gap analysis and identification of areas for improvement, sponsors and teams set-up, but the expected plant infrastructure just wasn't there. The plants were brimming with what appeared to be excessive stock in terms of raw materials, finished product and work in progress (including large amounts of rework and waste in some cases). The control rooms in all the plants, with one exception, were untidy and a lot of unnecessary equipment was evident – clothes lockers, coffee machines, a fish tank and an exercise bike being some of the extreme examples. This may have been a reflection of the strong unionised sites, which were also a very common theme, and were mentioned several times as a reason why things had been slow in implementation.

There was widespread use of computers with good clear mimic boards; alarms were also set with deviation limits on critical parameters. What was disappointing, however, was the lack of display or any kind of reference to KPIs, SOPs or product condition sheets. This was with the exception of one plant out of five companies visited.

The only area of consistency for all plants was safety – all plants had very clear policy statements and commitments to drive and improve safety. One approach involved having a large notice board stating company policy, with all employees signing the board to give their commitment to zero accident performance. Process-driven safety audits were again very common on all sites, with the best examples being carried out by the process teams themselves with schedules laid out months in advance. The safety performances of the plants visited were excellent – 38 years since the last lost time accident is certainly world class. If the UK could adopt the same level of commitment that is used to champion accident-free work areas into its application of WCM tools, it would be a much stronger industry.

5 MAINTENANCE EXCELLENCE

Aims

The purpose of this section is to understand how the sites visited approached maintenance and what processes they were using to improve the reliability of their assets.

Introduction

Clearly all the sites we visited undertook maintenance activities in one form or another. The mission team was interested in deriving any learning from how the host companies approached the subject. To this end it examined how their approach stood up against the following criteria:

- Use of benchmarking to determine current performance and areas for improvement
- Loss accounting including Pareto and involving multi-functional teams
- Use of improvement techniques such as root cause analysis
- Use of key maintenance metrics such as planned/unplanned; schedule compliance; work order backlog; schedule compliance; etc
- Training and development of all personnel so that they acquire the skills and knowledge to participate in a maintenance excellence programme

Learning points

The maintenance practices deployed were in general outdated and inefficient. It did come as a surprise but this was a particularly barren area for the team in terms of learning and witnessing best practice. In general the asset condition on the plants visited was good but the maintenance practices deployed would be regarded as outdated and inefficient in the UK. All the sites had engineering teams that had total responsibility for maintenance activities. 'Operators operate and mechanics fix' appeared to be the situation on all sites. Two companies were just embarking on a predictive/preventative maintenance programme (PPM) involving the operating teams and both organisations recognised they had a long way to go.

The majority of sites visited saw their approach to maintenance as a significant weakness.

The story was not all bad in terms of measurement though. Again the MEx companies already had robust measures of losses vs MPR, Pareto analysis, root cause analysis of failures, etc. One company had an excellent asset utiliser tool used by reliability engineers to gather hard data and focus improvement work.

Again the companies without a MEx programme were short on consistent systematic measures.

6 PEOPLE MANAGEMENT

Culture and climate

Attention to sustaining and developing the commitment of all at the site to its success was a feature of the leading operations visited. At the first organisation the site manager's door – which the visitors walked past – had a series of statements on his and hence the organisation's values posted on it.

Reward and recognition was also a feature of the better plants – simple and low cost, eg T-shirts, were used to signal achievement. At least one site used an away day to try to communicate values.

A climate survey approach was used by teams at one location to assess how the improvement programme was working, with in addition the use of a Dow review process which provided 22 measures on performance of individuals. This also incorporated 13 competencies which were used for recruitment. Although sounding complex, contact with operators seemed to confirm a pride in the operation and their individual roles.

Union relationships were seen as important by all the companies, and it was a feature of most of the plants that mention was made of the need to involve union representatives in discussions on changes. There was evidence of a staff vs payroll separation at some of the older and less chemistry-based units.

At least three plants used a formal process with a distinctive title, eg New Work Systems, Goal is Zero, Waste Free Manufacture, to describe their approach to management. The latter two were being used to link SHE performance to manufacturing in a positive way. They also avoided the use of the word lean with its connotations of low numbers. Where only SHE values were stressed manufacturing excellence seemed to take a bit of a back seat, which echoes UK experience.

All plant management included a significant number of more experienced personnel who had been on site for a number of years – in fact the length of service was much greater than was expected. A number of the plants had been on the same site for many years – in the case of one well over 100. The team was left to speculate that US pension schemes may be less generous than those in the UK, leading to easier retention of able staff.

These experienced personnel provided the leadership needed to ensure a sustainable culture – this was particularly apparent in two cases.

There was limited evidence of sharing know-how across cultures – the mission team's visit had encouraged two nearby plants' personnel to meet for the first time. At another, a new production manager from the group's larger plant had just arrived in order to release the more experienced man to assist an underperforming plant elsewhere.

The team's difficulties in securing visits also pointed to a limited interest in sharing experiences in the manufacturing arena, coupled with the limited number of process manufacturing plants which have entered, let alone won, any national manufacturing awards. This was similar to the UK position until more recently.

7 TRAINING AND DEVELOPMENT

As is so often the case the leading plants were committing significant resources to training, but within the sample there was some significant variation.

Minimum was five days/year and some did much more – one quoted up to three months off-job on critical processes and three months on-job to complete, although others with apparently similarly complex processes took much less.

Validation of training was a feature of the better plants. One validated all training every three years, and another on an infrequent basis. One other considered it ought to, but was not.

It was a feature of two plants that operators were trained in up to four roles, and the two leading plants had a reward system linked to levels of competence and job difficulty.

Training plans were not universal but the majority had a structured system for recording development and assessing performance at all levels. One at least used peer review. However no training matrices were on display at any of the plants, even where they existed.

Standard operations were not observed except at one plant – although 5S standards were seen at a number of locations.

There was limited evidence of the systematic training and development of team leaders as the key link in establishing and maintaining a continuous improvement culture.

The various organisations visited in the USA all had slightly differing approaches to their training and development needs. This was dependent on a variety of business factors including size, market dynamics (growing, mature), the type of business (speciality chemicals, bulk commodity, etc), profit margin, etc. However, one common thread throughout all of the organisations visited was the importance of SHE. All sites visited began with some form of safety induction and included a guided site tour. Employees were aware of the SHE metrics as these were very clearly posted around each of the sites. On one particular site, employees were encouraged to carry out safety tours and fill in small cards that were collected through a post box system around the site. The company had provided safety tour training for its operators to enable them to carry out such tours. The same company was also one of the original signatories to the USA responsible care programme and had very clearly used this as a vehicle to drive through change in the organisation. The process operators wrote the SOPs and certified each other upon completion of training in a particular area.

Auditing plays an important role in the SHE area using techniques such as safe and unsafe acts identification (SUSA) and hazard and operability studies at the design stages of projects. Training in these areas was very common in all the organisations visited.

All organisations held communications briefings at the beginning of each year to explain the business priorities to all staff for the next 12 months. Based on the business priorities, the sites individualised these priorities and set their own objectives for the year.

This was then disseminated throughout the organisations with further objectives for each individual being developed. This latter step tended to be carried out in smaller, area teams. One business, National Starch, took this a step further. Having communicated the key site targets to all staff, this was then translated into a poster signed by everyone to demonstrate commitment to achieving the site objectives. This had also been taken to the next level down, with individual departments developing their own charters with clear objectives and signed by all the staff in that department. Clearly, this ensures all employees are focused on the business objectives and their delivery. Annual performance reviews based on achievement of the objectives, sometimes using incentivised bonus schemes, are common.

It is also very common at shop floor level for the organisation to have a target for each individual to have a particular number of days training per year. This is focused on personal objectives developed from an annual appraisal. A typical figure of no less than 10 days is common.

To ensure the recruitment and promotion of the correct people, one organisation visited, DuPont, had empowered its operators in all aspects of training, from recruitment and appraisals to promotion reviews. One example is from the DuPont Kalrez plant where a three-legged approach to continuous improvement is being used, as shown in Exhibit 7.1.

New Working Systems focuses on people development. The initial recruitment process is carried out to ensure the employee is both competent to do the job and fits with the business and site culture. Operators rotate positions and can do 3-4 different tasks in the process. They have a role progression system with 13 competencies. Each operator has their own individual development plan and a development record book validating progress against the 13 competencies. There is also a formal assessment process. HR, the team and the coach for that section review potential promotions. The teams for each area (cell) direct themselves and share leadership. Also, tools such as 360-degree feedback are used. This has been taken to the point where

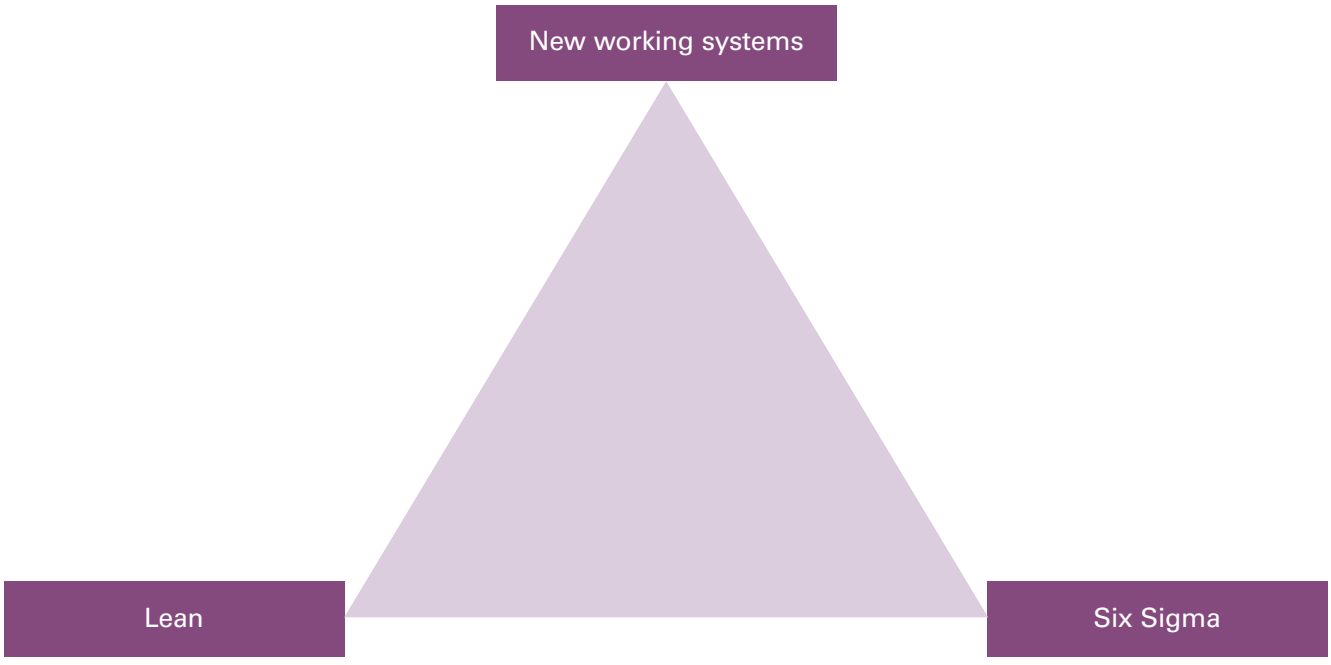

Exhibit 7.1 *A three-legged approach to continuous improvement*

the operators have developed their own promotion system and they even self-audit.

Multi-skilling in all of the organisations visited was evident. The level varied, but ranged from process operators having been trained to operate and carry out a variety of different tasks, to maintenance crews carrying out simple electrical and mechanical work.

Manufacturing excellence tended to vary between organisations. Six Sigma was widely applied as a technique in all of the organisations visited, but the extent it is used varied vastly. DuPont, for instance, has embedded Six Sigma throughout the organisation and is using it as a business management process. Training has been extensive, with over 1,500 black belts and 1,800 green belts currently operating. The training involves a four-week programme followed by completion of two projects, typically delivering $175k (£100k) per project before certification as a black belt. Accountants, also trained in the Six Sigma methodology, verify the savings.

All of the other businesses visited have trained black belts and green belts in much smaller numbers and use Six Sigma as a tool when it is required. Most organisations are using Six Sigma because of the structured methodology that leads to concrete savings. The methodology is being used across all areas of the business, including transactional areas.

Lean Six Sigma is also something used widely in DuPont. Other organisations are struggling to understand what this means and therefore where it fits within their organisation and what the training requirements are. In DuPont, Lean really means the removal of waste. All of the organisations visited were clearly aware of principles such as 5S, Kaizen, SMED, TPM, but evidence of these techniques being successfully used was limited. The best use of 5S was at the National Starch facility where the operators had clearly been trained in this discipline and recognised its benefits. Rohm and Haas used its own version called COPS (clean, organise, police, secure).

Rohm and Haas has a very clear view of its route to manufacturing excellence. In recent years, this has been largely driven through improved asset utilisation. Having developed their own asset utiliser software and written their own manufacturing excellence manuals, the manufacturing excellence team rolled the use of these tools out to the whole group, providing training and support. This also involved recruiting and training reliability engineers. The training involved using the asset utiliser software, refocusing on improving maximum proven rates and carrying out manufacturing excellence surveys to basically perform a gap analysis on each process. Whilst its use has not been mandatory, the benefits have sold the tools to other sites and more than 50% are using the tool since its introduction in 2003.

As mentioned earlier, there are some common threads throughout all the organisations. Clear communication of the business of objectives, breaking these down to relevant objectives at all levels in the organisation is essential to achieving the business goals. Many of the tools that are used are the same. However, it is the interpretation of their use between different organisations that changes. People remain the most important asset to any business and it is important that those people are not only recruited to meet the business needs and culture, but are trained in the right techniques to meet the business requirements.

8 MANUFACTURING EXTENSION PARTNERSHIP

The structure of public sector support for the process sector demonstrated that the US had come across some of the issues which have affected UK programmes in the past.

In particular the regional (in their case state) focus of activities proved to be unsuited to the needs of the process industry where supply chains cross the continent. However, no magic formula had emerged. A number of state programmes were being run by a single organisation which had allowed some transfer of learning.

The programme, which is their equivalent to the UK's DTI Manufacturing Advisory Service (MAS) programme, had been set up over some 15 years and had benefited from continuous funding over that period.
A consistent policy for improvement plus a commercial element which allowed the providers to benefit from the developments and hence sustain themselves more readily was, possibly unsurprisingly, a feature of the US approach.

The programme had recognised the need to tailor its offerings to the process sector – and had developed some interesting simulation games which will be further examined for use in the UK industry.

9 THE FUTURE – OBSERVED TRENDS AND DEVELOPMENTS

It was clear that the widespread apparent use of Six Sigma in the US is not as universal in the process sector as might be imagined. Although the larger corporations have clearly trained and developed their cadre of master black belts etc, this has not been universal or necessarily a prerequisite for excellent performance.

Where this was seen it had usually come from a sustained implementation of an improvement approach by the management team. Leadership was the key differentiating factor for the best plants seen.

The key step being taken by the leaders was the integration of Lean and Six Sigma methodology to drive improvement from all points in the organisation. This was explained by putting in place an overall programme of improvement which then allowed the tools to be picked up as necessary. The leaders' commitment to the training and development of the workforce was also exceptional.

The companies are beginning to try to learn from each other – again the scale of the US renders this a little more difficult. Within companies it was also clearly possible to develop a successful corporate centre of excellence which could market its services and add value over time.

It was noticeable that a topic of major concern in a European context – low cost production – was not at the top of everyone's agenda. Equally, energy costs were not a subject of significant complaint as they have become here.

There was little evidence that Lean or other improvement ideas were being applied to non-manufacturing functions more rapidly than in the UK.

The mission came back convinced that manufacturing excellence has no easy answers and that the tools and techniques which promise rapid gains must be deployed within a long-term framework of continuous improvement such as that shown. The successful plants had done this and were prospering.

The importance of identifying and retaining leaders in the continuous improvement area was clear, and the systematic training and development of such individuals is a clear source of competitive advantage to companies and countries.

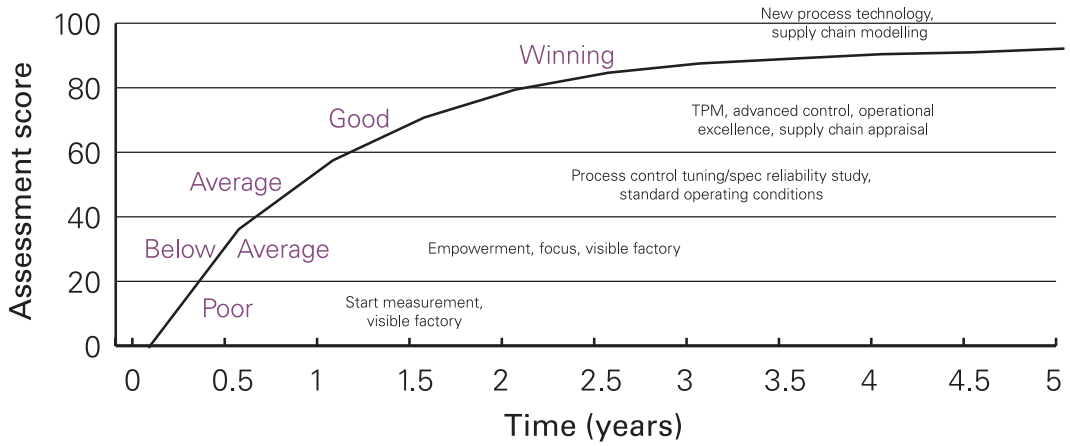

Exhibit 9.1

Graph showing assessment score against time

10 CONCLUSIONS

The US is very strong on manufacturing excellence leadership and most organisations visited have full-time employees working in this area. The factors underpinning the effectiveness of performance improvement programmes in the US are as follows:

- Leadership

There is very strong manufacturing excellence leadership, with the most successful plants employing a full-time leader with no other conflicting and time-consuming responsibilities. At National Starch success has been led by a former plant manager who had the advantages of 100% dedication and detailed local knowledge.

- Global forums

All companies visited held regular forums and an annual workshop to discuss manufacturing performance and share best practice. At Rohm and Haas, for example, the Vice President of Manufacturing and Operations has no line responsibility for manufacturing but chairs the global manufacturing council, which is made up of 12 manufacturing directors from subsidiary business units.

- Multi-skilled operators

Diverse means of engaging operators in improvement activities were seen during the mission. Regular off-line communications events were the norm, while involvement in Kaizen events and new systems were also prevalent. DuPont has an extensive programme designed to develop individual competencies beyond functional skills.

- Well-defined measurement criteria

Key performance indicators are widely used with the main categories being responsible care, productivity, maintenance, supply chain, quality and human resources/administration. While some companies use a small number of headline indicators to track how the whole programme is doing, others such as Arch Chemicals produce a single figure for use in inter-site benchmarking by adding together individual weighted figures.

To improve the sharing of best practice information, dialogues opened during a mission will now continue, a task made easier by the fact that all companies visited have plants in the UK.

Appendix A

ACKNOWLEDGMENTS

Without the assistance of a lot of people this mission would not have happened. The team were especially grateful to:

1 The host organisations across the US chemical industry which invested a lot of time and effort in providing the team with a very comprehensive view on manufacturing excellence in their industry. We were shown great hospitality wherever we went and hope to be able to return it one day.

2 The DTI Global Watch Service for its generous financial support and assistance with organisation, particularly Craig Wallbank of the DTI and Charlotte Leiper of Pera

3 Ron Moore and Jim Wallpole, US process industry contacts, for their support and guidance in selecting suitable organisations to visit.

4 Sarah Redfern of PICME who coordinated the mission and, despite having to shepherd an unruly bunch of men around the US, remained cheerful throughout, even when being searched yet again at another airport!

Appendix B

DELEGATE PROFILES

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Professor Munir Ahmad is Professor of Manufacturing Engineering and Subject Group Leader for Process Manufacturing and Design at the School of Science and Technology, University of Teesside, Middlesbrough.

He has over 25 years of international level experience working in universities, as a director of research centres and as a consultant for industry. He has four years' experience of working as deputy managing director in a petrochemical industries design and engineering company.

He is co-author of a book, *Benchmarking in the Process Industries*, published by the Institution of Chemical Engineers; founder of the International Conference on Manufacturing (www.faim.org.uk); European editor of quarterly journal Robotics and Computer Integrated Manufacturing, published by Elsevier; co-editor of 15 international conference proceedings; and co-author of over 80 journal and conference papers.

He has established Teesside Manufacturing Centre (www.tmc.uk.com) to support industry on manufacturing-related issues and undertake relevant training, research and development projects. The centre has assisted over 300 companies through various projects including the b2b project (www.b2b-mc.co.uk) jointly with the Warwick Manufacturing Group, Regional Computer Aided Engineering project (www.rcae.co.uk) and CIM centre.

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Allan Cowan is an engineering postgraduate from Edinburgh who went to work in the plastics manufacturing industry for ICI in a R&D role in the early 90s. The role developed into a plant support and development function that has been the background to becoming a chartered engineer with specialist skills in continuous improvement management. This training has served well the role of Continuous Improvement Manager at Innovia Films in Cumbria, where a large-scale improvement programme has now successfully been run for the last four years.

Allan believes in taking a very practical approach to continuous improvement by running multi-skilled teams that involve individuals from all levels within an organisation with a strong emphasis of these tools being applied to any area of a business inside or outside of manufacturing.

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Paul Daniels is a chartered chemical engineer with 19 years post-graduate experience in the process industry. From university he joined ICI and spent his early years providing process engineering support for improvement projects and new product development. He quickly moved into manufacturing, initially in a technical capacity, but has spent the last 13 years in plant and operations management.

Paul has worked on a number of sites in the UK in a range of sectors including speciality chemicals, polymers, plastics and bulk commodities. He has been based on the Runcorn site in Cheshire for the last eight years and his services, along with the business/site, were acquired by Ineos Chlor in 2001. The site manufactures chlorine and caustic soda via the electrolysis of brine as well as a range of chlorine derivatives and acids. The total site volume is currently 3 million tonnes per year.

He is currently the Upstream Manufacturing Manager responsible for the chlorine assets which produce over half the site volume and will soon include a new membrane chlorine plant. Paul's section employs over 500 people and includes all operating, technical, project and engineering resources to support the upstream plants in addition to a site services team that provide the utilities and infrastructure support to the whole site.

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Paul Ellwood is the Manufacturing Excellence Manager of Octel Corp, based at Ellesmere Port. He supports Operations Managers at Octel's manufacturing sites throughout the world by facilitating improvement projects and coaching in best manufacturing practice.

Originally a chemist by training, he has held a number of manufacturing roles within UK specialty chemical companies, including Operations Director of Hickson & Welch. He joined Octel in 2003 following two years as the Chemicals and Bioscience Cluster Development Manager of Yorkshire Forward. His professional interests include training, coaching and creative management.

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John Forrest is a chartered chemical engineer and scientist who worked in various industries and roles before joining Huntsman Tioxide in 1989. He is currently Group Process Technology Manager, which involves managing a team of engineers, scientists and technicians in a supporting function. This involves carrying out manufacturing improvement programmes, plant troubleshooting, project management and evaluation of capital investment opportunities.

Huntsman Tioxide has eight sites around the world and therefore the role involves a large amount of international travel. Six Sigma is currently being rolled out to the whole organisation and as a Six Sigma champion John was particularly interested to hear about the US experience in this area.

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Mark Lewis has been involved with manufacturing in the UK since he completed his master's degree in Systems Engineering at Lancaster in the early 70s.

After stints in a number of now defunct companies he decided to move into the chemical process industry, one of the UK's more successful sectors. Following spells in operations, maintenance and in business planning/market analysis, Mark moved into asset management and operations improvement in the development and launching of Eutech. This wholly owned ICI subsidiary focused on using technical know-how to improve the manufacturing performance of the chemical and related industries.

In working across the industry Mark was convinced that the scope for improvement was and is enormous. His main worry was that UK manufacturing plants were not improving fast enough to stay in front – or in many cases catch up with their competitors.

When it came, therefore, the opportunity to speed up the application of manufacturing improvement was too good to turn down. As chief executive of PICME, Mark is looking to bring world class performance within the reach of all UK process manufacturers.

Sarah Redfern
Manufacturing Improvement Engineer & Mission Coordinator

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Sarah has worked within manufacturing for 17 years and is a Charted Mechanical Engineer. She started her career at British Aerospace as a Mechanical Technician apprentice and progressed through project engineering roles including lean manufacturing implementation.

Sarah moved to the North East in 1995 to join Viasystems, Europe's largest printed circuit board manufacturer at the time, where she progressed through man-management roles including Shift Line Manager and Production Manager, responsible for a department of 130 people. As part of the role she was tasked with integrating all facets of operations, from materials management through to personnel management and manufacturing, and to develop processes and capabilities which enabled the company to create more capacity and higher technology to meet surging demands.

She continued her education, culminating in an honours degree in Mechanical Engineering, a diploma in Management and the NEBOSH qualification. In 2002 Sarah joined PICME as a Manufacturing Improvement Engineer. She is responsible for delivering improvements in manufacturing and support functions in terms of cost, quality or delivery performance at each

client's facility. The types of organisation can vary from bulk and specialist chemical manufacture, plastic/rubber compounding and component manufacture through to the pharmaceutical sector.

Appendix C

HOST ORGANISATIONS

Arch Chemicals Inc
www.archchemicals.com

Arch Chemicals is located on a 15-acre site in Rochester, New York, and employs 140 full-time staff. It is a global supplier of speciality chemicals and produces over 50 different products. The Rochester site is part of a group that employs over 3,000 staff and has a combined turnover of $1.2 billion (£670 million). The company is very aware of international competition, particularly from China.

The company has adopted a practice of combining responsible care with developing sustainable supply chains with the customers. This practice will enable it to achieve better planning and forecasting in order to deliver competitively priced products on make to stock (MTS) and make to order (MTO) basis to its valuable global customer base, including companies such as Procter & Gamble.

The product development process involves customers. Responsible care covers: safety, health and environment, compliance, conservation, continuous improvement and communications. The outcome is that clearly defined KPIs are displayed in the company. The responsible care objective is to achieve an injury rate of zero. The culture for continuous improvements has been achieved by the adoption of best practice tools and techniques which are considered appropriate to the circumstances. The company achieves improvements through the responsible care programme.

Arch Chemicals envisages itself competing in the global market business through the creation of an environment of good chemistry.

DuPont – Kalrez and Vespel sites, Newark and Delaware
www.dupont.com

DuPont is a large organisation employing 60,000 people worldwide, and with an annual turnover of $27 billion (£15 billion). It is one of the top three independent chemical companies in the world and is a world leader in a number of technologies and business sectors.

The company has embarked on a major change process using Six Sigma as the vehicle for delivering sustained improvement in performance.

DuPont has approached Six Sigma with the same degree of focus that earned the company the reputation as the world leader in safety management. Since 1999 it has trained over 18,000 green belts, 2,200 black belts and has 300 master black belts.

The two sites visited were not typical DuPont sites as they were both small (~200 employees each) and engaged in manufacturing component parts using DuPont resin raw material. The Kalrez site manufactured 'O-rings' for use in demanding chemical and thermal environments. The Vespel site manufactured moulded parts with enhanced physical properties, a proportion of which were one-off items manufactured to customer-specific requirements.

Both sites have embraced the corporate Six Sigma drive for improvement and have each delivered impressive results from their suite of projects. The safety performance on both sites was excellent, with the Vespel site maintaining the statistic of no Lost Workday Cases in its entire 38-year history.

Manufacturing Extension Partnership Management Services Inc (MEP MSI)
www.mepmsi.org

MEP MSI is a non-profit, strategic supply chain management company which provides a full package of back office management and growth-oriented services to manufacturing extension partnership centres, to maintain minimally acceptable impact measures (MAIM), realise cost savings, expand and diversify funding. It is a management consultancy that provides supply chain solutions to manufacturers across a wide range of industries. MEP MSI has a staff of over 250 professionals in over a dozen offices throughout the United States.

The company's mission is to assist manufacturers – both small and medium manufacturing enterprises (SMEs) and larger prime contractors and original equipment manufacturers (OEMs) – develop effective supply chains.

The MEP MSI story began when it implemented – with the support of National Institute of Standards and Technology Manufacturing Extension Partnership – drastic changes in Maine MEP's operations that proved successful in turning the centre around. Maine MEP became the model for transforming other MEP centres into highly effective programmes providing world-class services to small and medium-sized manufacturing enterprises (SMEs) at lower costs.

It has since established itself as the managing agent for the MEP programmes in Arizona, Florida, Maine, Massachusetts, New Hampshire and New Mexico.
In addition, it is providing selected back office management and growth oriented services to more than 20 centres.

National Starch Food Innovation, Kansas City plant
www.foodinnovation.com

National Starch Food Innovation is a worldwide leader in specialty starch technology and manufacturing for the food industry. It can trace its roots back over 120 years to a series of mergers by regional starch producing companies in the US to form the National Starch Company of New Jersey. Its headquarters are still in New Jersey today. The company prides itself on its science-based approach to delivering new types of functionality out of agricultural raw materials, and it has remained at the forefront of ingredient technology as the food market became more sophisticated and demanded better answers.

National Starch Food Innovation is a business unit of National Starch & Chemical Company. A member of the ICI Group, National Starch & Chemical has worldwide sales in excess of $3 billion (£1.7 billion), employs nearly 10,000 people located in 155 facilities in 36 countries on six continents.

The Kansas City operation became part of National Starch Food in 1985. Using potatoes, wheat, corn and rice, it manufactures a range of 200 products that can be divided into two groupings: adhesives and starch. Working closely with its 200 employees it has made significant strides in the implementation of its waste-free manufacturing programme.

Rohm and Haas – Croydon
www.rohmhaas.com

Rohm and Haas is a speciality materials company with a $7 billion (£3.9 billion) annual sales turnover. Its employs around 17,000 people (about 14,000 in manufacturing) at more than 100 manufacturing sites in 27 countries. The site visited is in Croydon, near Philadelphia. Discussions were held with the asset management group, whose stated mission is to:

- Improve reliability – more uptime
- Improve capacity – more product
- Improve costs – reduce operating costs
- Improve asset structure – more capacity without capital expenditure

The team consists of 14 people, including two Six Sigma black belts, two reliability/maintenance engineers and a manufacturing excellence manager. Also present during most of the discussions was the VP Manufacturing and Operations who chairs the Manufacturing Council.

Rohm and Haas first started the Manufacturing Excellence journey in 1993 focusing on reliability and maintenance, benchmarking the performance of its sites. In 1999 it developed its own software called Asset Utiliser (AU) that is now widely used throughout the organisation to look at equipment reliability and asset utilisation. In fact, over 50% are using the AU software, with potential savings of $59 million (£33 million). At the same time the company developed a competency model called POWER.

P Process technology
O Operating excellence
W Workforce practices
E EHS
R Reliabilty

The POWER model together with AU has been used to drive through manufacturing excellence improvements. A very heavy emphasis is placed on AU and AU improvement.

Six Sigma was started in the late 90s, initially for black belt training. And so far the company has about 200 trained green belts. Six Sigma is regarded as another tool that can be used where appropriate if it will help to improve performance and reduce costs.

Solutia, Indian Orchard Site, Springfield, Massachusetts
www.solutia.com

The Indian Orchard site is one of ~26 manufacturing facilities that Solutia currently owns and operates throughout the world. It has been part of the Solutia organisation since 1997, although manufacturing has taken place on site for over 100 years. In 1904 it was part of Fibreloid and in 1937/38 it was bought by Monsanto.

Worldwide, the company employs ~5,700 people, of whom 560 people work on this site, with 400 employed in manufacturing, 120 in R&D and 40 in sales. The four main products are: Saflex (polyvinyl butyral (PVB) interlayer used in the construction of safety glass, predominately on car windscreens); Butvar (resin used in the manufacture of Saflex); Resimene (coating used in the food industry – recently announced the sale of to Ineos); and Gleva (adhesives and melamines – site assets sold to UCB then Cytex but operated by Solutia personnel).

The annual sales turnover of the full organisation is ~$2 billion (£1.1 billion). The company has seen a lot of change over the last two years with the sale of the Gleva and Resimene operations to third parties and the file of bankruptcy chapter 11 in December last year. The focus through this period has been cash flow and working capital with a large commitment towards continuous improvement projects.

Solutia is headquartered in St Louis, Missouri with regional headquarters in Louvain-La-Neuve, Belgium; Sao Paulo, Brazil; and Singapore.

Synthetic Organic Chemical Manufacturers Association (SOCMA)
www.socma.com

SOCMA is the leading trade association which has served the specialty-batch and custom chemical industry since 1921. It has 300 member companies which represent all sectors of the industry from small specialty producers to large multinational corporations, with more than 2,000 manufacturing sites,100,000 employees and producing 50,000 products valued annually at $60 billion (£34 billion).

Batch chemical manufacturers play a key role in the US chemical industry, producing intermediates, specialty chemicals and ingredients that are used to the depth and expertise of this industry sector are vital components of the US chemical industry and contribute significantly to US global competitiveness.

SOCMA is the recognised voice of batch chemical manufacturers known for its commitment to performance improvement, entrepreneurial attributes, innovative initiatives and constructive impact on regulatory and legislative decisions. It promotes performance excellence and creates value for its members.

SOCMA accomplishes its mission through the implementation of three strategic directions:

- Accelerating the potential for members' growth by maximising commercial and networking opportunities
- Increasing public confidence in the chemical industry
- Influencing the passage of rational laws and regulations that allow members to operate in a productive manner as good corporate citizens

Appendix D

LIST OF EXHIBITS

Appendix E

GLOSSARY

~	approximately
>	greater than
<	less than
BPR	business process reengineering
CIA	Chemical Industries Association (UK)
CpK	process capability
FMEA	failure mode and effect analysis
JIT	just in time
KPI	key performance indicator
LTA	lost time accident
m^2	square metre
MEx	manufacturing excellence
MPR	maximum proven rate
MTO	make to order
MTS	make to stock
OEE	overall equipment effectiveness
OTIF	on time in full
PICME	Process Industries Centre for Manufacturing Excellence (UK)
PM	preventative maintenance
PPM	predictive/preventative maintenance programme
PVB	polyvinyl butyral
RCA	root cause analysis
SHE	safety, health and the environment
SMED	single minutes exchange of dies
SOCMA	Synthetic Organic Chemical Manufacturers Association (US)
SOPs	standard operating procedures
SPC	statistical process control
SUSA	safe and unsafe acts identification
TPM	total productive maintenance
TQM	total quality management
WCM	world class manufacturing

Other DTI products that help UK businesses acquire and exploit new technologies

Grant for Research and Development – is available through the nine English Regional Development Agencies. The Grant for Research and Development provides funds for individuals and SMEs to research and develop technologically innovative products and processes. The grant is only available in England (the Devolved Administrations have their own initiatives).
http://www.dti.gov.uk/r-d/

The Small Firms Loan Guarantee – is a UK-wide, Government-backed scheme that provides guarantees on loans for start-ups and young businesses with viable business propositions.
http://www.dti.gov.uk/sflg/pdfs/sflg_booklet.pdf

Grant for Investigating an Innovative Idea – is designed to help UK businesses develop innovative products, processes or services that are in the very early stages of development.
http://www.dti.gov.uk/innovative-idea/index.htm

Knowledge Transfer Partnerships – enable private and public sector research organisations to apply their research knowledge to important business problems. Specific technology transfer projects are managed, over a period of one to three years, in partnership with a university, college or research organisation that has expertise relevant to your business.
http://www.ktponline.org.uk/

Knowledge Transfer Networks – aim to improve the UK's innovation performance through a single national over-arching network in a specific field of technology or business application. A KTN aims to encourage active participation of all networks currently operating in the field and to establish connections with networks in other fields that have common interest.
http://www.dti.gov.uk/ktn/

Collaborative Research and Development – helps industry and research communities work together on R&D projects in strategically important areas of science, engineering and technology, from which successful new products, processes and services can emerge.
http://www.dti.gov.uk/crd/

Access to Best Business Practice – is available through the Business Link network. This initiative aims to ensure UK business has access to best business practice information for improved performance.
http://www.dti.gov.uk/bestpractice/

Support to Implement Best Business Practice – offers practical, tailored support for small and medium-sized businesses to implement best practice business improvements.
http://www.dti.gov.uk/implementbestpractice/

Finance to Encourage Investment in Selected Areas of England – is designed to support businesses looking at the possibility of investing in a designated Assisted Area but needing financial help to realise their plans, normally in the form of a grant or occasionally a loan.
http://www.dti.gov.uk/regionalinvestment/

The DTI Global Watch Service provides support dedicated to helping UK businesses improve their competitiveness by identifying and accessing innovative technologies and practices from overseas.

Global Watch Information
Global Watch Online – a unique internet-enabled service delivering immediate and innovative support to UK companies in the form of fast-breaking worldwide business and technology information. The website provides unique coverage of UK, European and international research plus business initiatives, collaborative programmes and funding sources.
Visit: www.globalwatchservice.com

Global Watch magazine – distributed free with a circulation of over 50,000, this monthly magazine features news of overseas groundbreaking technology, innovation and management best practice to UK companies and business intermediaries.
Contact:
subscriptions@globalwatchservice.com

UKWatch magazine – a quarterly magazine, published jointly by science and technology groups of the UK Government. Highlighting UK innovation and promoting inward investment opportunities into the UK, the publication is available free of charge to UK and overseas subscribers.
Contact:
subscriptions@ukwatchonline.com

Global Watch Missions – enabling teams of UK experts to investigate innovation and its implementation at first hand. The technology focused missions allow UK sectors and individual organisations to gain international insights to guide their own strategies for success.
Contact:
missions@globalwatchservice.com

Global Watch Secondments – helping small and medium sized companies to send employees abroad or receive key people from another country. Secondments are an effective way of acquiring the knowledge, technology and connections essential to developing a business strategically.
Contact:
secondments@globalwatchservice.com

Global Watch Technology Partnering – providing free, flexible and direct assistance from international technology specialists to raise awareness of, and provide access to, technology and collaborative opportunities overseas. Delivered to UK companies by a network of 22 International Technology Promoters, with some 8,000 current contacts, providing support ranging from information and referrals to more in-depth assistance with licensing arrangements and technology transfer.
Contact: itp@globalwatchservice.com

For further information on the Global Watch Service please visit
www.globalwatchservice.com

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