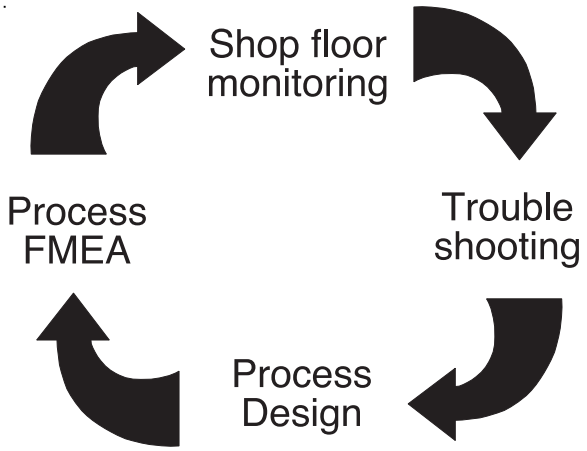
QPAC Handbook

How to implement integrated quality systems in a factory



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Contents

Summary

This document describes how you can implement quality systems in a factory to improve both the quality of product produced now, and the quality of future product designs. In factories where these systems have been installed, the experience has been that wasted production has been reduced, and quality and customer satisfaction have been improved.

The handbook provides results and details of the experience of implementing integrated quality systems at a number of aluminium foundries. However, the benefits are not limited to foundries – they should be applicable whether your company makes cakes or circuit boards.

What is in this handbook?

Advantages of the quality systems implemented

Overview of the integrated systems

Details of each of the systems implemented

Details of the databases that hold the factory information

This material is also available along with example code on-line on the QPAC Web site (http://www.aber.ac.uk/~dcswww/Research/arg/QPAC).

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1 Advantages of integrated quality systems

Many supplier companies are being pressured by their customers to improve their product quality. Standards such as QS9000 and Ford's Q1 emphasise the need for continual process and product improvement.

Researchers at the University of Wales Aberystwyth working with three aluminium foundries have pioneered a solution which may help many quality departments to meet the challenge for continual improvement. The solution can be gradually implemented, and the details of the solution are available in this document, along with some software to assist with the solution on the associated Web site.

The solution at the foundries addresses both short term problems of monitoring and fixing immediate difficulties, and the long term challenge of improving processes so that problems do not reoccur.

This is achieved by a number of integrated database components to:

- monitor and process customer concerns
- provide troubleshooting assistance based on previous similar problems
- indicate the major challenges to quality within the company
- provide consistent process planning for new products
- assist in process FMEA

Each of these components is carefully designed to need the minimum possible input from the foundry staff, while simplifying the quality work that they already need to carry out because of existing quality standards.

The overall effect is to provide a powerful mechanism for making sure that all of a company's experience is used to improve its product quality. The implemented systems close the loop between dealing with problems on the shop floor and feeding that experience back into design. The main benefits are improved response to customer concerns and a long term improvement in new designs for processes.

Because the complete system is implemented as a number of separate, but linked components, companies can use their existing computerised quality systems as part of the solution, and can implement a complete solution gradually, making improvements to their quality systems as additional components are added.

2 Overview of QPAC systems

2.1 Introduction

The quality systems that have been implemented give assistance in four areas of activity:

Shop floor monitoring
Process concern reporting
Statistical process capability recording
Quality feedback systems

Troubleshooting
Process concern reporting
Problem matching assistance and advice

Process Design
Process planning system
Process detail recording

Process FMEA
Generation of outline process FMEA using real factory data

This section of the handbook will give a brief summary of each quality system in each area. Much of the rest of the handbook is taken up with the details of each of the systems – what they do, how they do it, and the underlying databases that support each activity.

2.2 Shop floor monitoring

These systems assist in recording shop floor performance. This is done for three purposes:

- to record the quality of the factory's performance for input into process design
- to ensure that problems are dealt with as quickly and effectively as possible
- to provide the ability to control the quality of the factory's performance

2.2.1 Process Concern Reporting system

The Process Concern Reporting System (PCR) system records all customer concerns along with significant problems that are detected before a product leaves the factory. Problems are dealt with using the 8D problem handling system.

The PCR system makes sure that all process concerns are dealt with by appropriate staff, and enables the quality manager to keep track of the status of every process concern.

It also records information that can be used in process FMEA generation, and in troubleshooting (see later).

2.2.2 SPC system

The statistical process capability (SPC) recording system provides facilities for recording how well the factory is producing its products within required tolerances. This information is used within the process FMEA generation process, to provide information about how likely it is that planned processes will operate within desired parameters.

2.2.3 Quality feedback systems

The information in the PCR system can be analysed to provide performance information for the factory. It is possible to identify the primary concerns as problems continue to occur in those areas over time. Because the process concern reports are categorised by the factory process with which the problem occurred, it is possible for the software to identify the processes where the most problems occur. The quality manager can then consider whether the measures being taken to address problems with that process are effective, or whether a special task-based action team should address the needs of that process.

2.3 Troubleshooting systems

These systems assist with the task of ensuring that any problems occurring in the factory are dealt with as efficiently and effectively as possible.

2.3.1 PCR system

When a problem occurs with a factory process, the PCR system outlined earlier provides support in several ways. It provides a framework within which troubleshooting can occur. It makes sure that a team is assigned to the problem, that the customer is told of what is being done about the problem, that the 8D problem solving methodology is followed, and that the problem is solved satisfactorily.

2.3.2 Problem matching help system

Experience of solving a particular problem has often been stored in a very patchy manner in the past, and been lost over time. Where people leave the company, experience can deteriorate very quickly. Because the PCR system logs the process of solving particular problems, it is possible to replay that process at a later date. In QPAC, the solutions to problems have been stored in a methodical way.

The problem solving help system makes that experience available in a painless and useful way. A description of the new problem will be entered into the PCR system while recording the details of the process concern. This description can then be matched against previous process concern reports, and solutions to similar problems in the past can be made available to the problem-solving team. This ensures that valuable past experience is always available to factory staff.

2.4 Process design

When deciding to manufacture a new process, the QS9000 standard dictates that a process plan should be produced. The process design software within QPAC supports the production of a process plan, and allows the user to provide details of the capabilities and risks attached to each process.

2.4.1 Process planning system

The process planning tool provides automated assistance for the production of a process plan. An "approved" list of processes is shared between the process planning tool, and the other software within QPAC. Of course, where new processes are introduced into the factory, it is possible to add to the list of approved processes, but it does ensure that different process plans will use consistent descriptions of the same processes. Previous process plans can also be amended to make a new one, in the case where a very similar product has been produced in the past, or the production process for an existing product is being changed.

The production of a process plan is a necessary part of many quality assurance processes, and so a tool to help produce a smart, consistent process plan is useful in its own right. Within QPAC, it also provides the basis for the production of a process FMEA report.

2.4.2 Process detail recording

This is a support process for FMEA. It allows the user to examine and change a list of the failures that can occur for each process, and to add further details of each failure.

The processes and the process failures are the same ones that are used in process planning, and in the PCR system for reporting problems.

When a factory is first using the QPAC systems, some processes will be added during process planning, some processes and failures will be added in the PCR system, and some failures and their details will be added at this stage. As time goes on, most of the details about processes and failures will already be present in the system, and there will be little to add at this stage.

2.5 Process FMEA generation

This software generates a first version of the process FMEA report for a process described with the process planning tool. It uses the information from process detail recording, along with information from the PCR system and the SPC system. The PCR system provides information about the frequency of actual failures that have happened in the foundry in the past when performing the same process. This can be used to produce the likelihood value associated with each failure on each process. The SPC recording system provides information about the likelihood that a particular tolerance requirement can be met, and that can also affect the likelihood of particular failures.

The process designer can examine the output from the process FMEA generation system and fill in values that the system has not been able to produce, and add comments or further information.

FMEA is a process with the main aim of detecting possible problems and changing the process to avoid them where possible. This means that production of the report is not an end in itself, but a means to an end. The designer needs to use the FMEA report to focus on likely production problems, and to design them out of the process.

3 Process concern reporting

The Process Concern Reporting System (PCR) system records all customer concerns with the product, and significant problems with the product that are detected internally before it leaves the factory. Problems are recorded, planned and dealt with using the 8D problem handling method.

The PCR system makes sure that all process concerns are dealt with by appropriate staff, and enables the quality manager to keep track of the status of every process concern. It also records information that can be used in process FMEA generation, and in troubleshooting.

The PCR system provides software support for the type of manual quality system that exists in many companies. It is possible to buy similar software as standalone products. The drawback with using an existing product is its lack of flexibility. We have not come across such a product which allows access to its database records from other software generated by the user. For example, the process concern reporting system described here uses the same descriptions of process as are used to plan new processes (see section 7), and the troubleshooting system is able to match a new problem description with existing PCR records.

Whenever a process problem occurs, the information is recorded as a process concern report. Actions may need to be taken, both to solve the immediate problem, and to try to prevent further recurrence of the same problem. There are four stages to dealing with a process concern, and this section will describe each of them in turn:

- Initial reporting of a process concern
- Assigning responsibility for the process concern
- Solving the problem
- Verifying the solution

3.1 Initial reporting of a process concern

Take an example problem: a number of aluminium castings are returned to a foundry because they do not meet the quality requirements of the customer. The foundry staff need to take down as full details of the problem as possible, set up a team to deal with the problem, and give an initial reaction to the customer.

The PCR system aims to make entry of the data as easy as possible. This is achieved by filling in as much information automatically where that can be done, and by providing many of the other inputs as menu lists where the user can just click on the correct answer. The four screens containing problem details can be filled out within a few minutes by an experienced user.

Figure 3.1 shows the first screen when a new PCR is raised. There are a number of details on this screen:

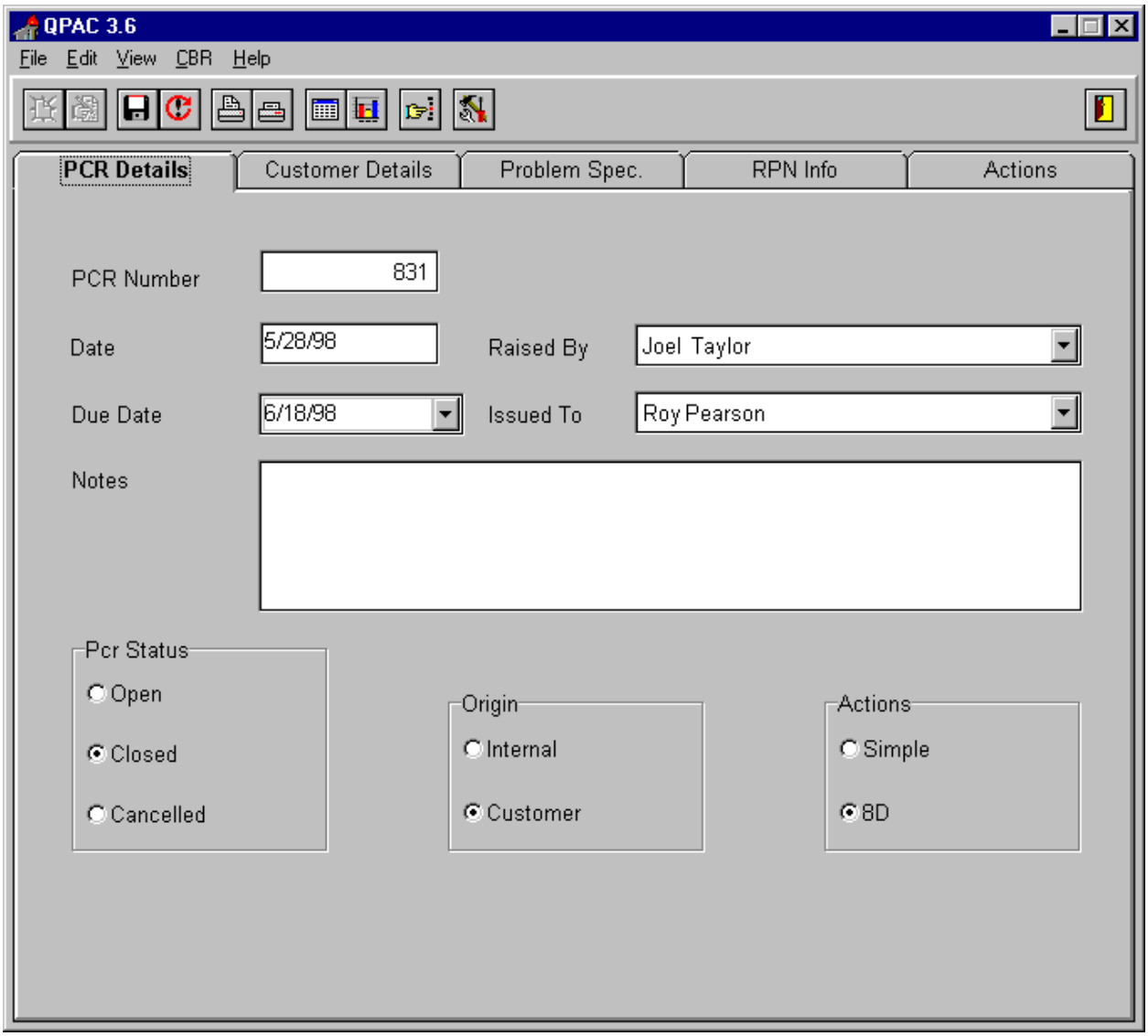

Figure 3.1: Basic PCR details

PCR Number	This is a unique identifier for the new concern. It is automatically assigned by the PCR system when a new PCR is created.
Date	This is the date the new PCR was created - automatically assigned.
Due date	The date that the PCR should be completed by - automatically assigned the default response time, but can be altered.
Raised by	Person within factory who accepted the complaint from customer.
Issued to	Person given responsibility for solving the problem.
Notes	Space for extra information about the situation.
PCR status	When a PCR is created, it is Open. It only becomes Closed when it has been solved to the quality manager's satisfaction.
Origin	Whether the customer raised the problem or it is internal.
Actions	Some internal problems need to be recorded, but do not merit full 8D actions.

Figure 3.2 shows the second screen of details to be filled in for a PCR. These concern the customer . When the PCR system user selects the customer name from a list of all customers, the address and customer reference number are filled in automatically. The possible customer names and other details are taken from an existing sales database. A default contact name can also be found in the database, but this can be overridden if the contact for this particular problem is different.

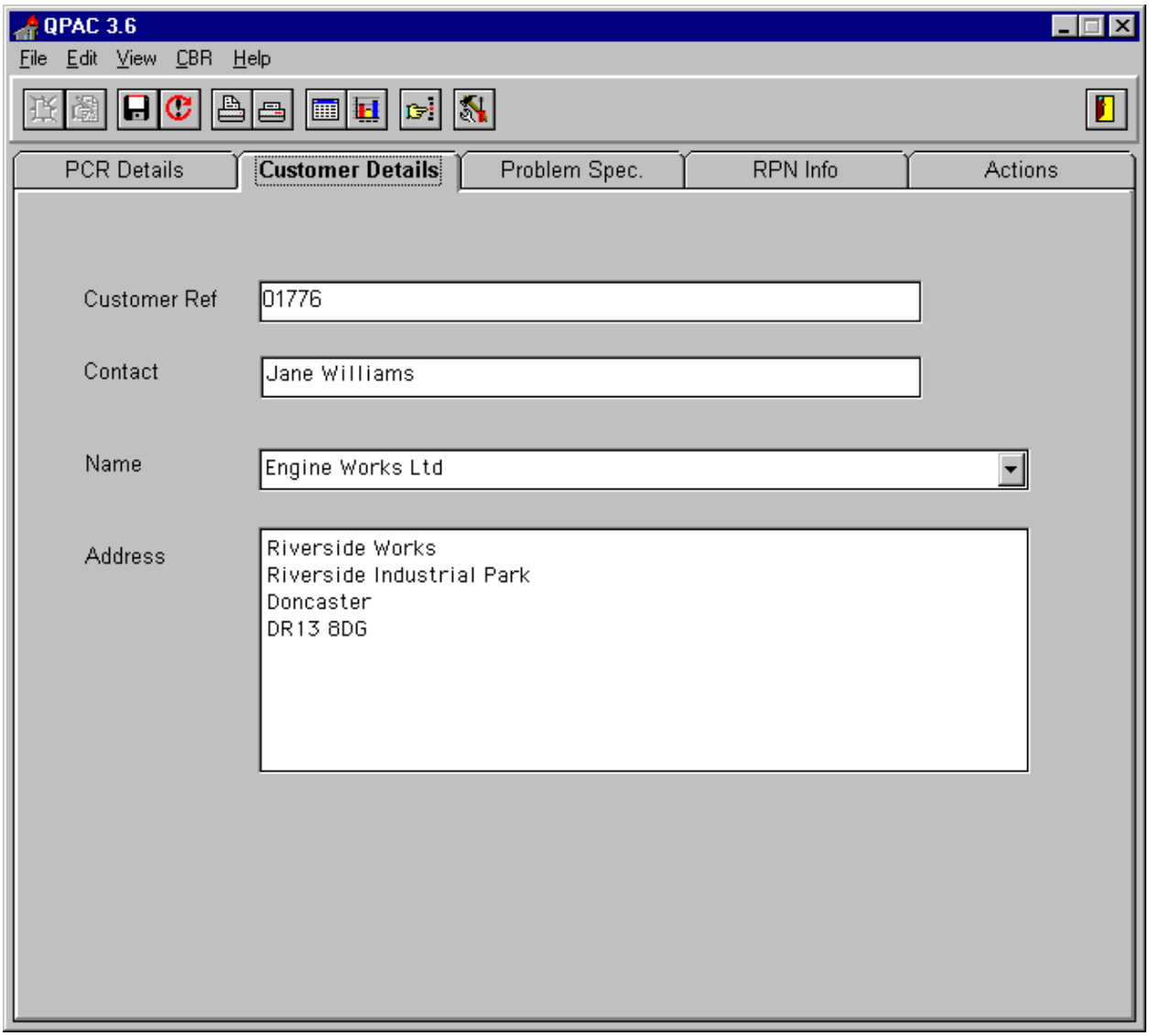

Figure 3.2: Customer details

Once the customer has been recorded, it is time to take details of the problem. Figure 3.3 shows the first of two screens for doing this. For the aluminium foundries, problems are associated with a die/part number and with a process. Once the customer has been selected on the previous screen, the user can be given a choice of just the dies relevant to that customer a much easier list to choose from than all dies. The prompts on this screen would need to be changed somewhat for an application other than a foundry – die number and part number might be combined in a product ID number.

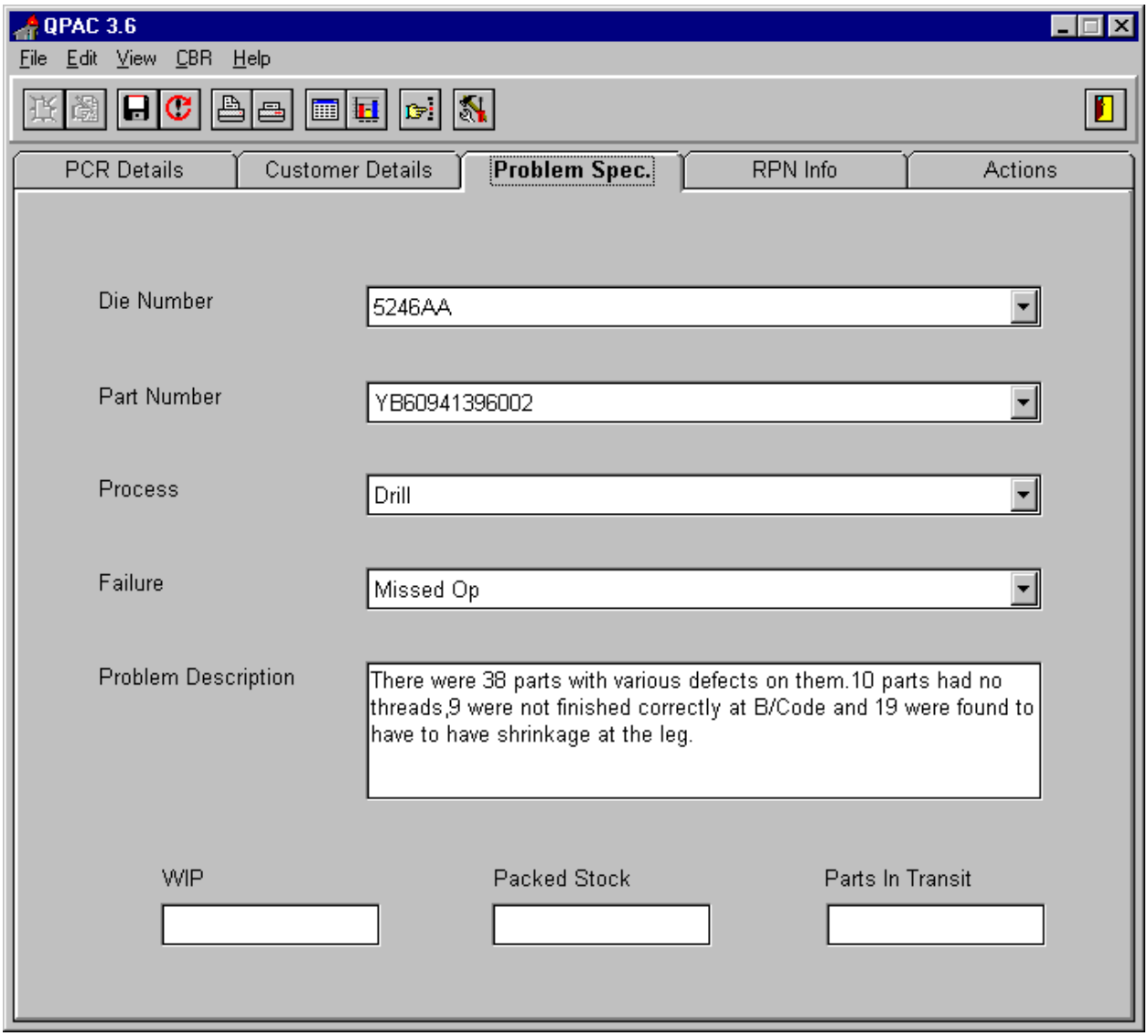

Figure 3.3: Problem details (1)

Either the die number or the part number can be entered, depending on which of them the user has to hand, and the other is obtained from the database.

The user must then select the process where the problem occurred. In the example given, it has been identified as a problem which occurred when drilling the parts. Having identified it as a drilling problem, there are a number of different kinds of problem that can occur with drilling, and the user has identified that an operation was missed out. Further details can be entered into the textual problem description. The three fields at the bottom of the screen are prompts to the user to check that any further work on the same part (in progress, already packed, or already in transit to the customer) is also checked to ensure that the same problem does not occur there.

The list of processes and possible associated failures is a separate database table that is used by many of the integrated quality systems within QPAC.

The next screen allows the user to record the impact of the problem. It is presented in terms of risk priority numbers (RPNs). This is a concept used in FMEA: values can be assigned to each of Severity, Occurrence and Detection (called Reaction here), and these numbers can be multiplied to obtain an overall impact factor for the failure.

The values from 1 to 10 for each of these categories have been mapped on to concepts that the user will understand. For example, "Return by customer" might be a 10 on a scale of 1 to 10, whereas "Sort by manufacturer at user location" might only be an 8.

This information is not of great use during problem-solving, but is invaluable for planning new processes, as it measures the impact of problems that have occurred in the past.

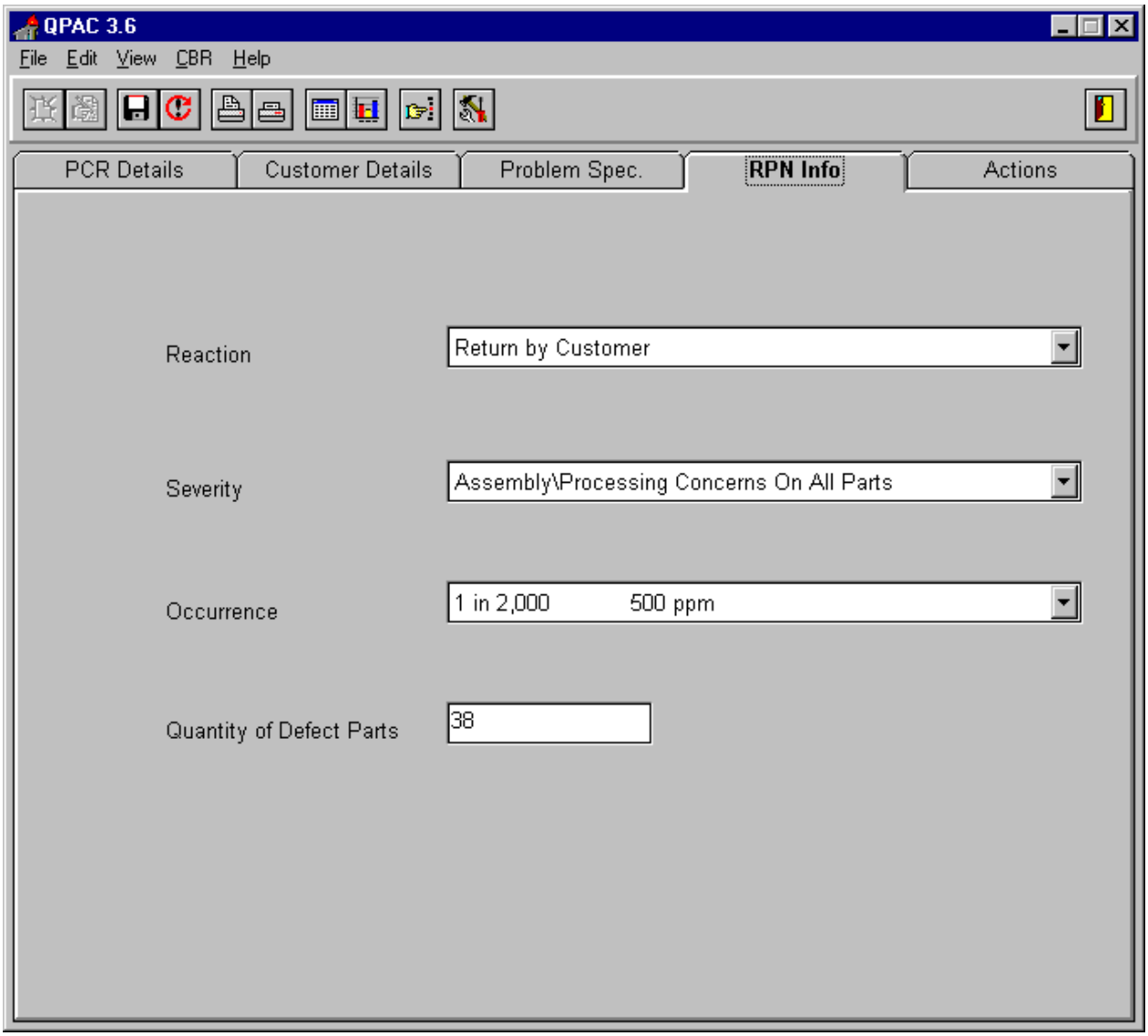

Figure 3.4: Problem details (2)

3.2 Assigning responsibility for the process concern

The final screen of the PCR system (titled ACTION) deals with the rest of the mechanism of solving a Process Concern. Once the details of the PCR have been entered, a team is assigned to solve the problem. Figure 3.5 shows the subscreen for choosing a team. All possible team members are listed on the right, and the user can select a team appropriate to the problem, adding them to the team list on the left. The person responsible for the team has already been chosen (see figure 3.1)

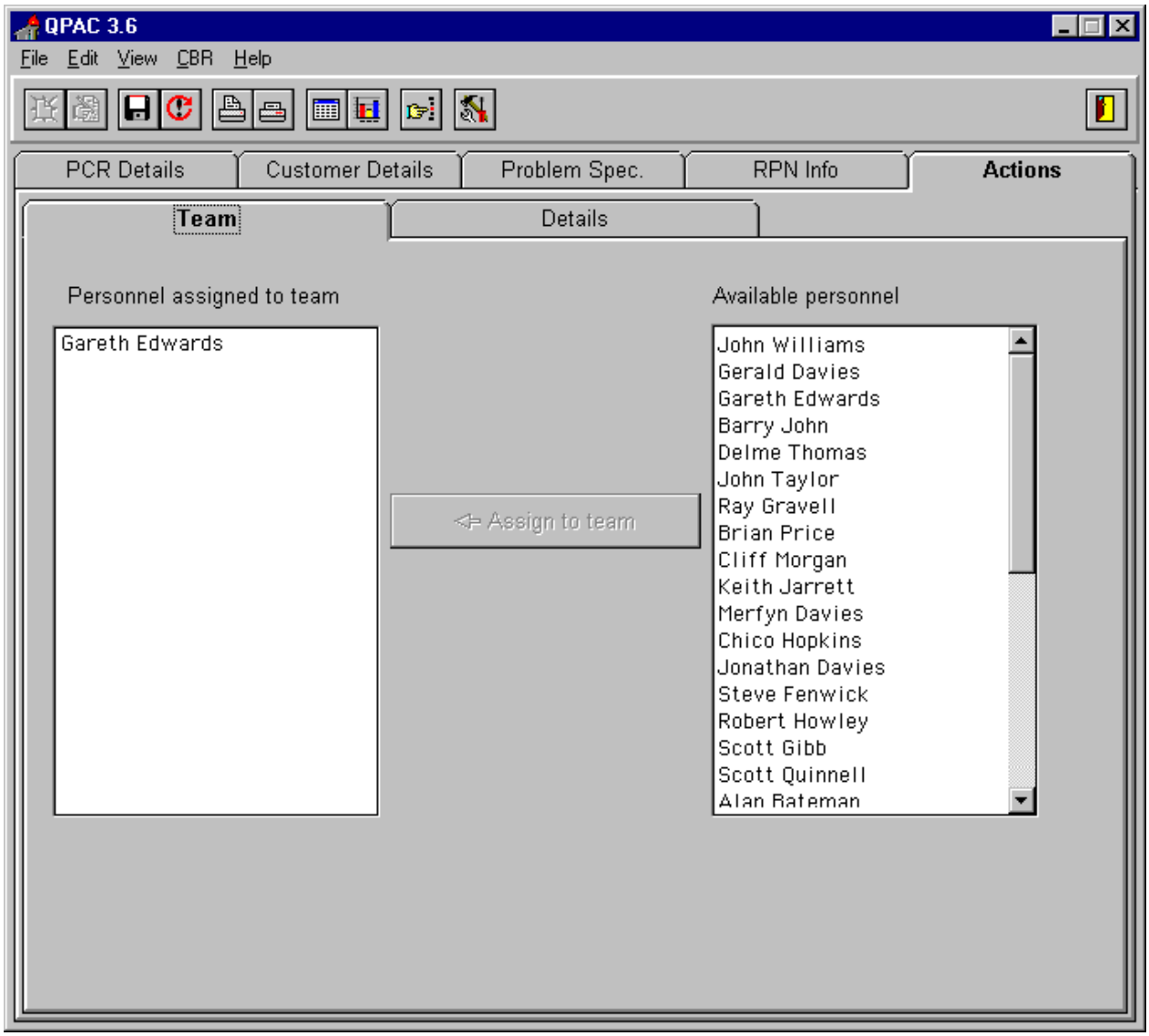

Figure 3.5: Choosing a team to handle the problem

At this point, the PCR system can export a fax to Microsoft Word for sending to the customer. It acknowledges the process concern, and gives details of who within the foundry is responsible for solving the problem, and by when.

3.3 Solving the problem

The PCR system can provide assistance for solving problems in the foundry. It can match the problem description with previous foundry problems, informing the team what actions were successful in previous similar problems, and which actions were not successful. This facility is described in more detail in section 6.

Whether there are previous relevant solutions or not, the team is required to solve the present problem. As they do this, they fill in the details of the solution in the 8D form as shown in figure 3.6. The fields on the form are specified in QS-9000

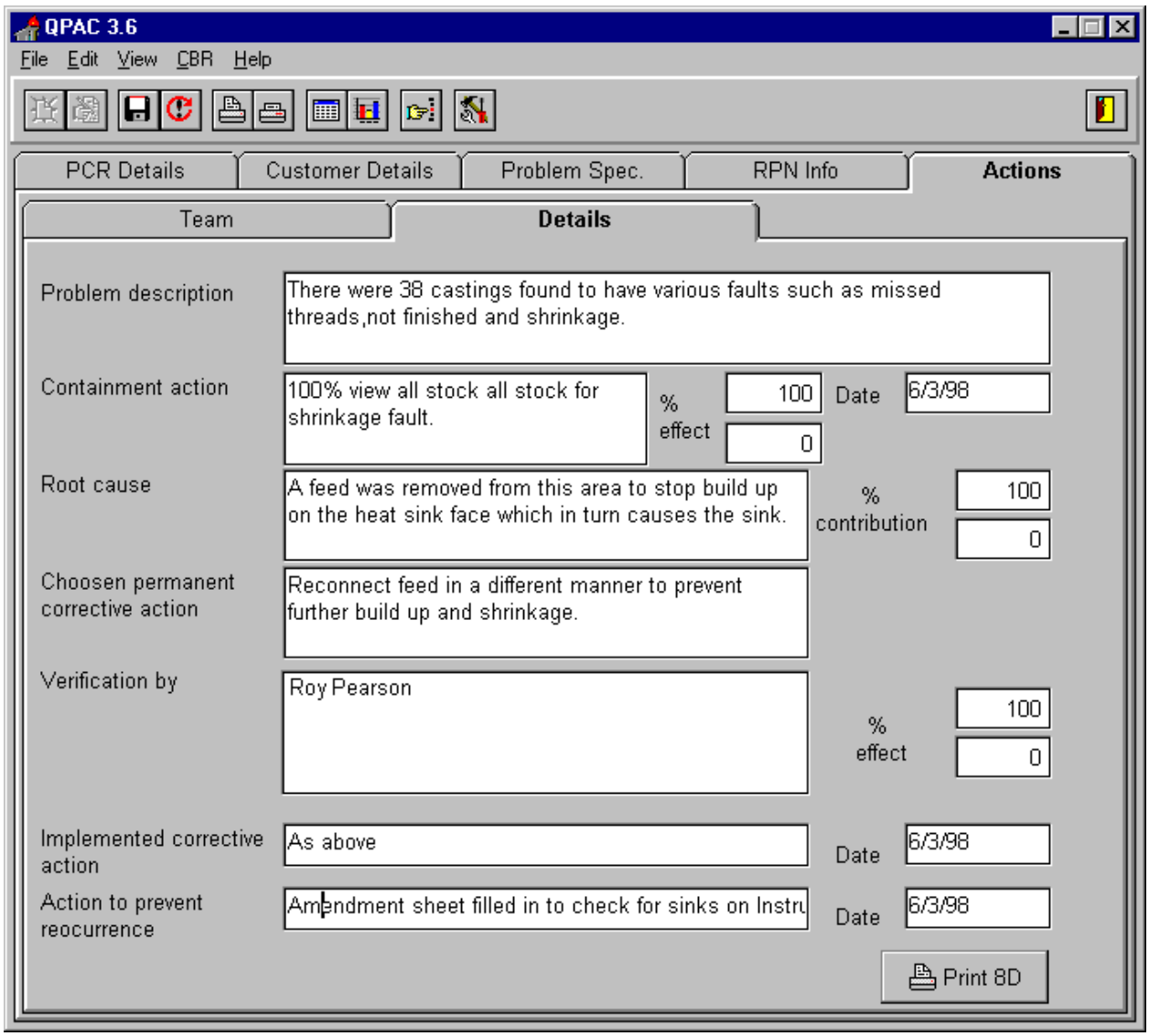

Figure 3.6: Giving details of the solution to the process concern

3.4 Verifying the solution

Once a solution acceptable to the team has been reached, the quality manager can verify that an acceptable solution has indeed been found and implemented. A complete 8D form as specified in QS-9000 can be exported to Microsoft Word, and printed for storage and for faxing to the customer (if needed).

The PCR can then be closed (see figure 3.1).

Until this position has been reached, the system provides facilities for the quality manager to keep tabs on the status of every PCR raised.

4 Statistical process capability recording

The statistical process capability (SPC) recording system provides facilities for recording how well the factory is producing its products within required tolerances. This information is used within the process FMEA generation process, to provide information about how likely it is that planned processes will operate within desired parameters. It can also be consulted by designers to find out what tolerances are reliably achieved during manufacture. Summary information is recorded about the reliability of production of significant features of the product.

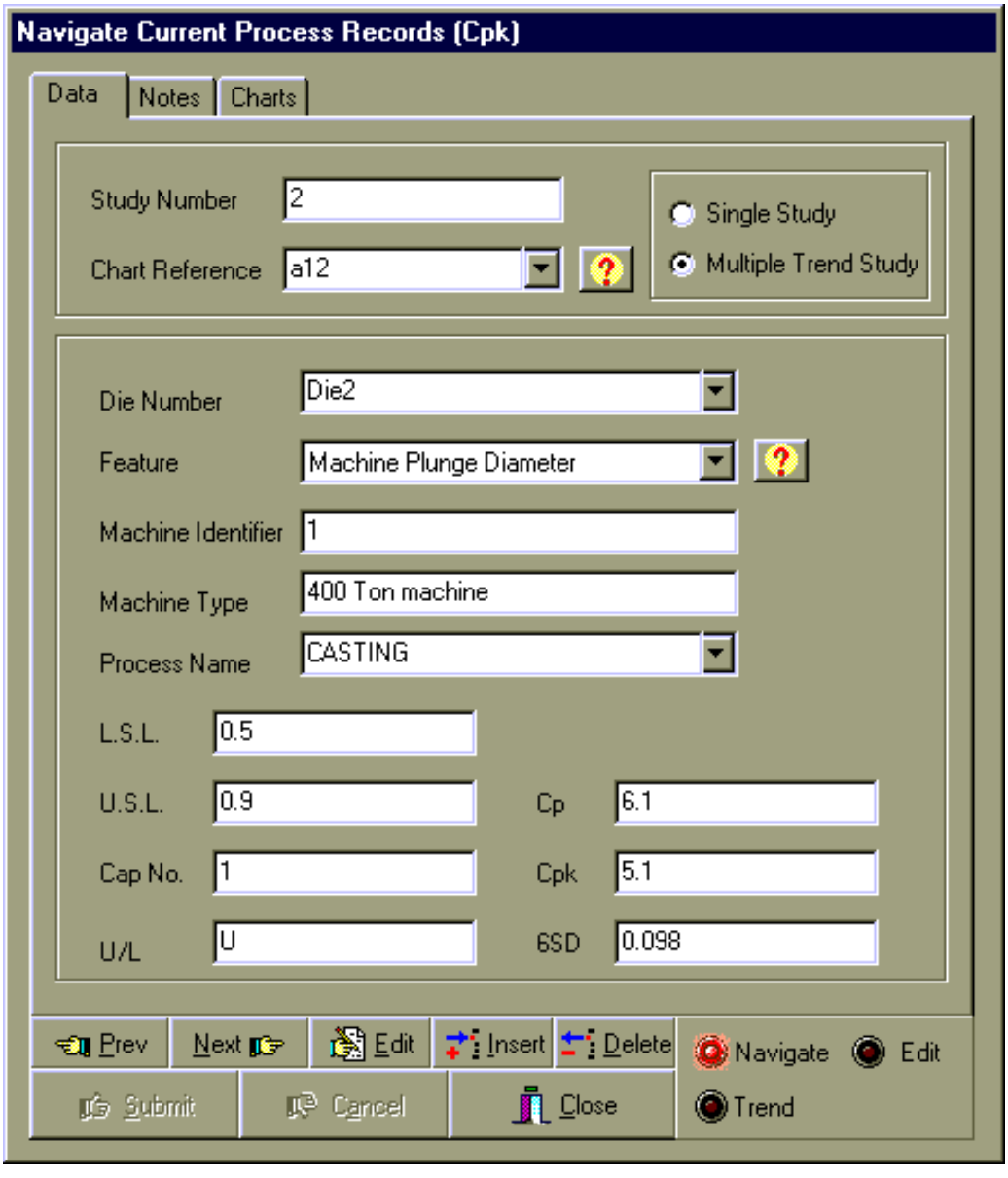

Figure 4.1: Extract from SPC recording system

5 Quality feedback systems

The information in the PCR system can be analysed to provide performance information for the factory. It is possible to identify important concerns where problems continue to occur in those areas over time.

Because the process concern reports are categorised by the factory process with which the problem occurred, it is possible for the software to identify the processes where the most problems occur.

The quality manager can then consider whether the measures being taken to address problems with that process are effective, or whether a special task-based action team should address the needs of that process.

Several types of summary reports are useful to the quality manager:

Reports on numbers of PCRs: The system can provide information on number of PCRs occurring in any period. This can be used to monitor trends in PCRs over time, for example, numbers of PCRs raised per month over several years.

Reports on status of PCRs: It is useful to know how many PCRs have not been closed at any point in time, and to know how many have not been dealt with within the target time for closing PCRs. This provides feedback on how well the factory is dealing with customer problems. Again, seeing this as a trend over time provides feedback on whether problems are growing. The results of the reports are also available within the PCR system as selectable lists, so that the quality manager can examine the detail of longstanding PCRs, to see why they have not been closed.

Analysis of PCRs by category: PCRs within a period can be broken into categories, so that the quality manager can identify any problem areas. Within the foundry, useful categories are: process where problem occurred, type of problem, product being produced, customer raising PCR. With these kinds of reports, the quality manager can identify whether there is a problem with a particular process or a specific customer, and take action accordingly.

The PCR system provides facilities for specifying what reports are required, and can then produce them automatically at specified times. So the quality manager might specify:

- weekly reports on outstanding PCRs
- monthly reports on numbers of PCRs raised each month over the previous six months, on PCRs per customer, and on PCRs per process
- yearly reports on PCRs for each type of problem, for PCRs per customer and for average length of time that a PCR is open

6 Problem matching assistance

When a new process concern is raised because of a production problem, the solution is often produced in an anecdotal manner: "I remember seeing a similar problem on the Product-o-matic machine about four years ago. We solved it like this....". Such solutions rely on the appropriate people still working for the company, being available to participate in problem solving, and remembering that the similar problem happened.

Now that process concerns and their solutions are recorded in a systematic manner, a more formalised way of accessing past solutions to process concerns is available. When a new process concern is raised, and its details have been entered into the PCR system, the user can request that the system match the description of the new problem with previous problems, and show solutions to similar problems. The user can then examine the matching PCRs and select the solution of a problem similar to the present problem and implement it.

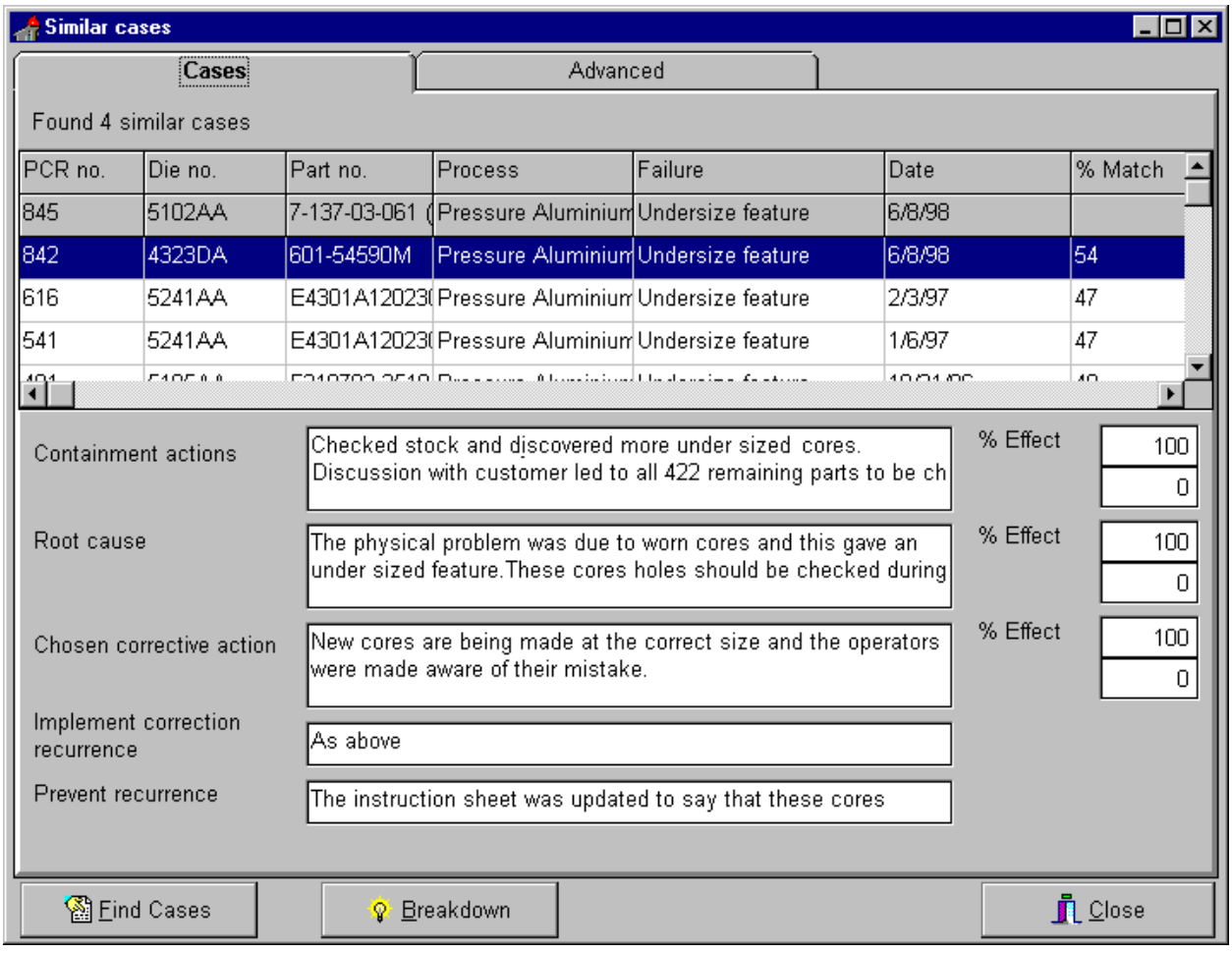

Figure 6.1: Re-using information on solutions to past problems

Figure 6.1 shows an example of the result of matching a new problem to past problems. The greyed out row (PCR number 845) is the present problem. The row in white on

black (PCR number 842) is the old PCR whose details are presently shown beneath. The old PCRs are listed in order of how well they match with the new case, and if there are several that match equally well, then the most recent one is shown first.

The matching with previous PCRs is done using the following criteria:

> *Process*: Problems with the same process might need similar solutions.
>
> *Failure type*. If the failure type was the same, then the likelihood of the same solution is increased.
>
> *Die*: If the failure is on the same product, then the likelihood of the same solution being needed is increased.
>
> *Part category*: Similar process concerns often occur because particular qualities are desired in a product for a specific market area. For example, the computer industry are more concerned about surface finish on aluminium parts than the car industry. When a new product is added to the system, it is classified by type and similar types can then be matched.

In order to get a perfect match, all of the criteria should match, but if that was the case, the user should be asking why the previous PCR did not solve the problem (and it did not solve it, as it has reoccurred). Typically, the process and failure might match, and perhaps the part category.

The problem matching assistance facility provides valuable help for engineers when they are trying to solve a problem as efficiently as possible. It supplies easy access to past experience, and can avoid the costly repetition of past mistakes – the solutions in the PCR system will have been tested out, and approved by the quality manager before the past PCR was closed.

7 Process planning system

When deciding to manufacture a new process, the QS-9000 standard prescribes that a process plan should be produced. The process design software within QPAC supports the production of a process plan, and allows the user to provide details of the capabilities and risks attached to each process.

The process planning tool provides automated assistance for the production of a process plan. An "approved" list of processes is shared between the process planning tool, and the other software within QPAC. Of course, where new processes are introduced into the factory, it is possible to add to the list of approved processes, but it does ensure that different process plans will use consistent descriptions of the same processes. Previous process plans can also be amended to make a new one, in the case where a very similar product has been produced in the past, or the production process for an existing product is being changed.

The production of a process plan is a necessary part of many quality assurance processes, and so a tool to help produce a tidy, consistent process plan is useful in its own right. Within QPAC, it also provides a firm basis for generating a process FMEA report, as described in sections 8 and 9. A version of the QPAC process planning tool is provided on the Web site as a standalone piece of software. Within the complete QPAC system, it is much more closely linked to the FMEA generation software.

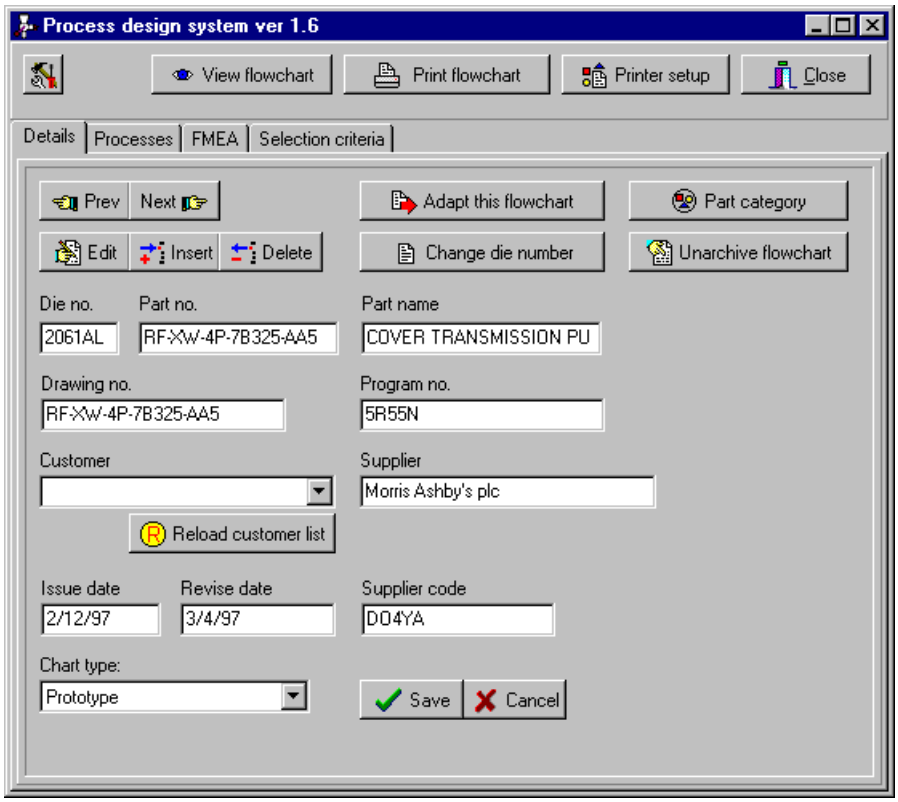

Figure 7.1: Summary Details Form of Process Planning Software

Figure 7.1 shows the initial screen of the process planning tool. Many process plans are variations on previous plans, and so the user can choose to adapt an existing plan for use in planning a new process. Some users have a number of common template for plans which can be adapted.

The user can also record the part category of the new product, for use in process FMEA production and in troubleshooting (much later in the lifecycle). Once a process plan is approved, it can be archived, making sure that it is not unintentionally changed.

Figure 7.2 shows some of the details of a plan. The user can add items to the plan, selecting the type of operation to be carried out, the process involved in the operation, and giving a more detailed description linked to each step in the plan.

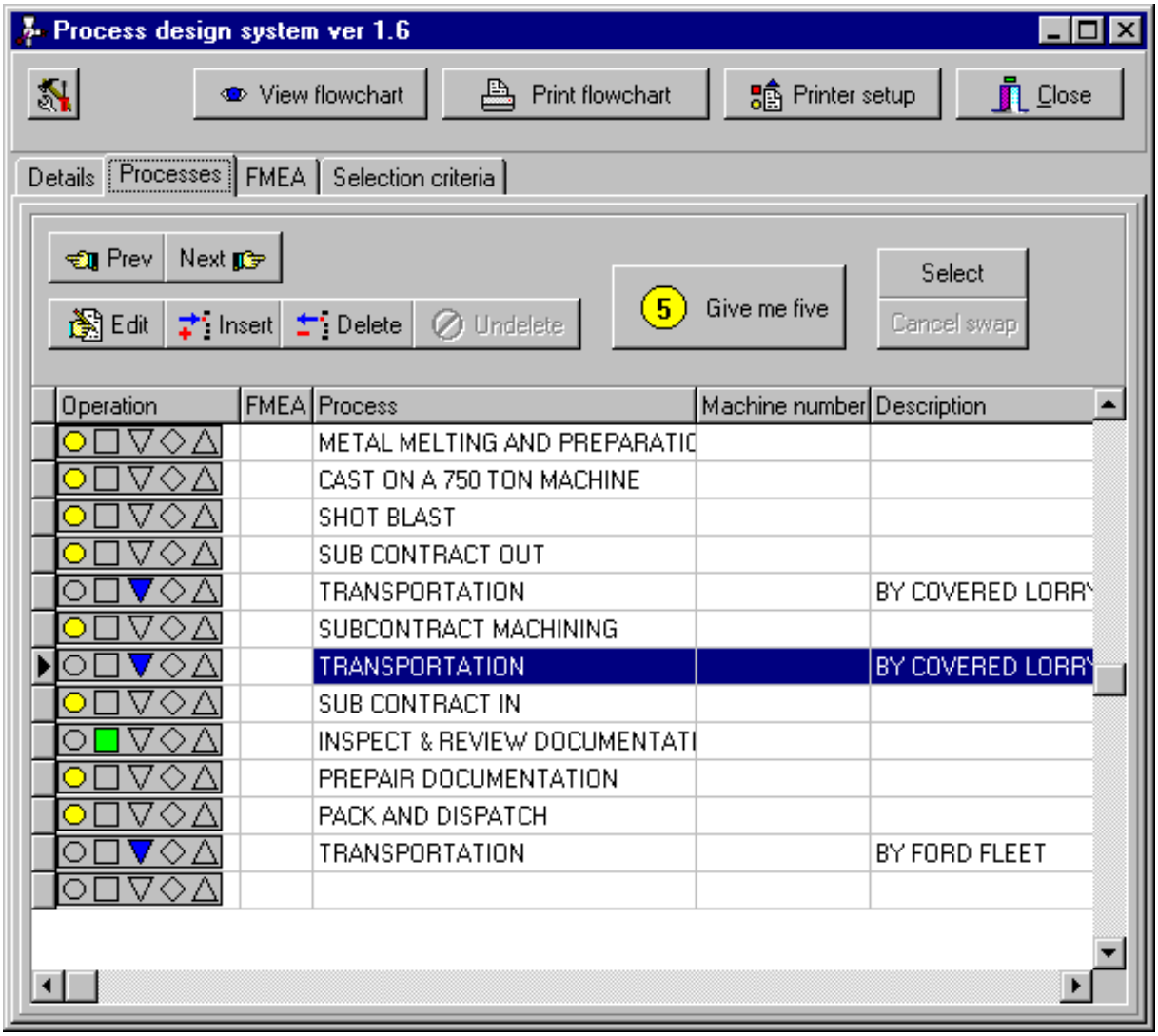

Figure 7.2: Details of a Process Plan

Facilities are provided to enable the user to add extras steps to a plan, and to manipulate the plan's contents until it faithfully represents the intended processes to be carried out in manufacturing the new product.

Process plans can be printed out in the format given in the QS-9000 quality standards, and sent to the customer. If changes are needed as the process is developed, then they can be done, and an updated die number given to the product if necessary. When the process is established, the process plan can be archived – frozen as a correct description of the process.

8 Process detail recording

Further details of processes are needed in order to perform process FMEA. This piece of software allows entry of further information about the processes that have been listed in the process plan. Each process can fail in a number of characteristic ways. The process detail recording software allows entry of the possible failures of a process, and the implications of each failure.

The same list of processes and their possible failures is used in the PCR system, as well as for process planning and process FMEA. When a factory is first using the QPAC software, some processes will be added during process planning, some processes and failures will be added in the PCR system, and some failures and their details will be added at this stage. As time goes on, most of the details about processes and failures will already be present in the system, and there will be little to add at this stage.

Figure 8.1 shows the screen for setting up details of processes and failures. Most of the screen shows the possible failures for the CASTING process. As one of the key processes in the foundry, this is a process with many possible common types of failure.

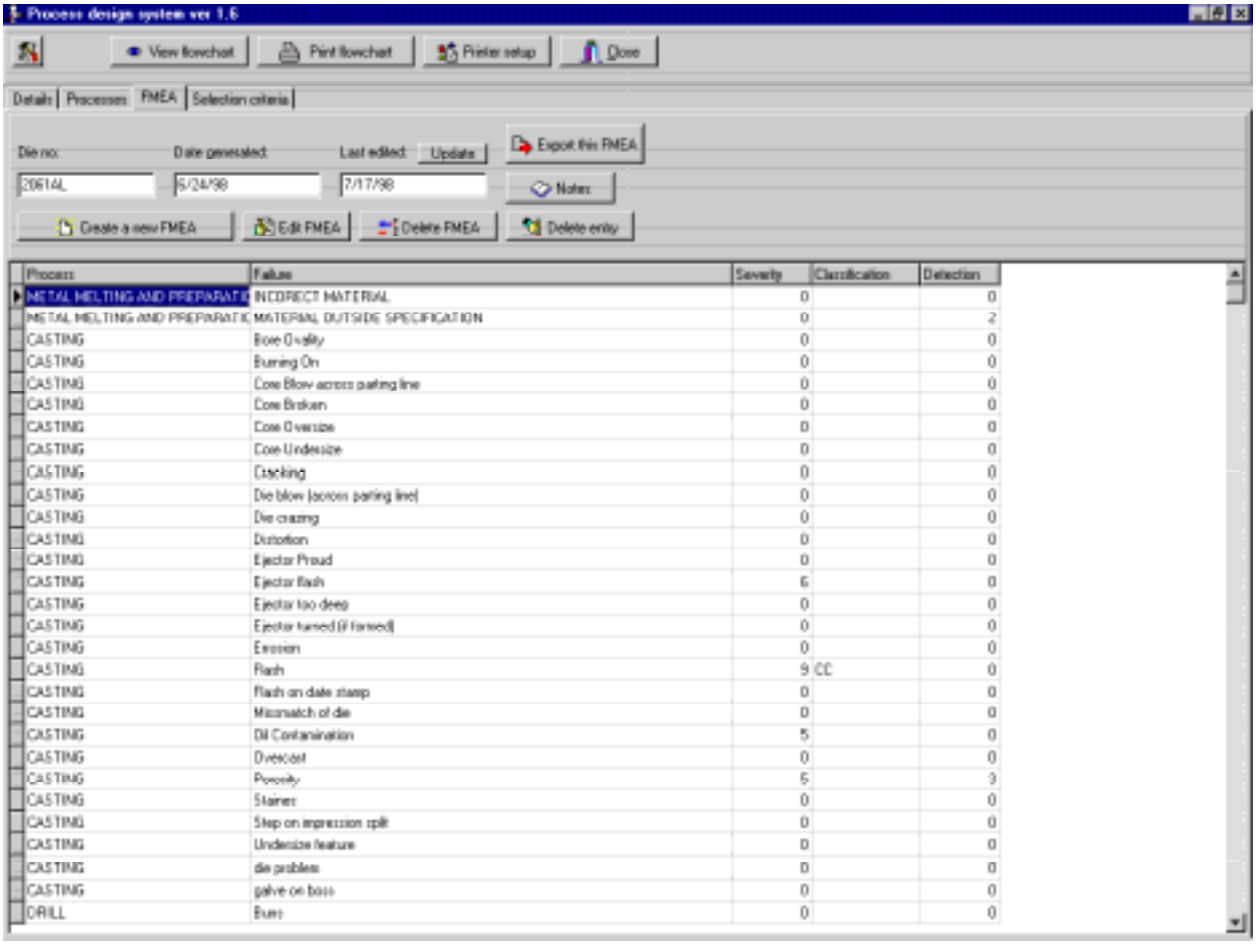

Figure 8.1: Setting up the failure details for processes

Each row in figure 8.1 describes a process and one of its associated failures. The other three columns provide the default Risk Priority Number values for the process/failure pair. This is used when producing an FMEA report. Each column has a value for one of three aspects of the failure: its Severity, Occurrence and Detection. Each of these is scored on a scale of 1 to 10, with 10 being the most significant. The overall RPN is calculated by multiplying the three values together, and both the independent values and the overall RPN are then used when acting on the FMEA report.

Figure 8.1 illustrates that many of the values in this table are unused. Only significant values have been filled in – for example, for the severity of flash occurring when casting: a perennial and difficult problem. For the most part, the actual values in the FMEA report are calculated from foundry experience, and section 9 gives details of how that is done.

9 Generation of outline process FMEA using real factory data

Much of the information recorded and used in the ways described in previous sections of this document can be brought together to generate a process FMEA report for a new process being planned. This will highlight potential problems with the new design, allowing the designers to focus on the significant problems and design them out.

Previous information of use includes:

The process plan developed in section 7. This gives details of the processes that are part of the manufacture of the product. The user can mark common processes (such as transportation to the customer) as not being of interest during FMEA generation, thus cutting out unnecessary rows from the FMEA report.

The failure information and values described in section 8. For each process to be included in the FMEA report, there should be a list of associated failures. These can be used to generate all of the rows of the FMEA report – one row for each failure on each process. Where RPN values (severity, detection, occurrence) have also been entered, those values can also be transmitted to the FMEA report.

The process concern information recorded in section 3. This gives details of the real problems that have occurred in the foundry. A list of PCRs with the same process, same failure and same part category is generated for each possible process and failure. The details on the PCRs are used to generate values for severity, occurrence and detection for the process/failure pair.

The SPC information entered in section 4. Where a process has been noted to have a specific feature or tolerance requirement, previous SPC records are consulted to see how well the foundry has achieved similar tolerances in the past, and the occurrence rating will depend on the results.

This information is automatically compiled for inclusion in the FMEA report *at the time that the FMEA report is compiled*, and stronger weight is given to more recent experience. This helps to make the FMEA report into a 'live' document. When new PCRs are raised, or SPC values change, that will be reflected in the FMEA report produced.