



Romeo Engine Plant (Abridged)

The Purpose of the Romeo Engine Plant is to produce the highest quality production engines in the world that meet all of our customers' requirements at a cost lower than the competition, and to develop teams of employees who are the best engine builders in the world.

Mission and Operating Philosophy, Manufacturing Handbook
Romeo Engine Plant, August 1989

The Romeo Engine Plant (REP), located in a rural area about 50 miles north of Detroit, was one of six North American engine suppliers of Ford Motor Company. From the early 1960s to mid 1980s the Romeo production facility had been used by Ford Motor Company to produce tractors. During this period, the Romeo Tractor Factory employed 2,000 unionized workers to produce about 10,000 tractors per year. In early 1984, corporate headquarters decided to phase out tractor production because of declining demand and increased foreign competition. In June 1987, the doors of the tractor factory were closed and locked for the last time. The 2,000 laid-off employees of the Romeo Tractor Factory had little hope of ever returning to their jobs.

In early 1986, Ford Motor Company began searching for a site to locate a new engine plant. Several management teams submitted proposals for the new engine production facility. George Pfeil, plant manager of the Dearborn Engine Plant, submitted a proposal to re-open the Romeo site for this purpose. After an extensive evaluation process, Romeo was selected as the new site, with George Pfeil appointed to become the plant manager. In 1993, the line organization (see **Exhibit 1**) of REP consisted of the plant manager (George Pfeil); two area managers, Lonnie Prater for machining and Bill Yowan for assembly, who reported directly to Pfeil; and 26 teams that reported to either Prater or Yowan.

The main production facility of REP was in a building covering more than 1.1 million square feet. During 1992, REP produced 400,000 engines in two engine models: a 4.6 liter, 2 valve engine used in the Lincoln Town Car, Ford Crown Victoria, and Mercury Grand Marquis, and a 4.6 liter, 4 valve engine used in Ford Motor Company's Lincoln Mark VIII luxury car. Sales of these automobiles were strong and Ford Motor Company was continually introducing new car models that would use the Romeo engines. By 1996 REP expected to produce more than 800,000 engines per year.

Cost of goods sold in 1992 was about 75% direct material, 23% manufacturing overhead, and 2% direct labor.

Professors Robert S. Kaplan and Amy Patricia Hutton prepared this case as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

Copyright © 1997 by the President and Fellows of Harvard College. To order copies or request permission to reproduce materials, call 1-800-545-7685 or write Harvard Business School Publishing, Boston, MA 02163. No part of this publication may be reproduced, stored in a retrieval system, used in a spreadsheet, or transmitted in any form or by any means—electronic, mechanical, photocopying, recording, or otherwise—without the permission of Harvard Business School.

The Romeo Quality Process

The Romeo Quality Process (RQP) was established to ensure that customer expectations about product performance were understood, deployed and controlled in the manufacturing and assembly processes. The RQP was a disciplined approach to total process design and planning that would minimize in-process variation and virtually guarantee that customers would get Zero Defect Parts with minimum variation. The primary elements of the RQP included:

- Forming teams that were responsible for product and manufacturing engineering, quality, production, systems, and supplier relationships (for materials, machine tools, and gauging equipment).
- Establishing target levels for product/process characteristics reflecting customer expectations and the required process capability levels.
- Defining the process to meet or exceed the process capability requirements.
- Selecting process control methods consistent with the nature of the process and sources of variation identified by the RQP planning process.
- Implementing the control plan on the production floor.

To emphasize the importance of a Zero Defects Philosophy, George Pfeil had eliminated incoming inspections and rework at the plant. If a supplier provided a defective part that was subsequently detected, the supplier was billed for the full loss caused by the defective part. Three years ago, a supplier had to pay for a \$6,600 engine repair that was caused by a broken valve spring (an item that cost about \$.05). The no rework policy required that a defective part had to be scrapped as soon as the problem was detected, with the scrap costs assigned to the work team responsible for the defective part.

Romeo had extended this no rework philosophy outside the factory as well. Under its Engine Exchange Program, dealers or assembly plants who detected a problem with an engine that could not be fixed with a minor repair, were requested to pull the problem engine out of the vehicle, replace it with a new engine, and ship the defective engine back to REP. Romeo's quality personnel tracked daily any quality problems reported by assembly plants and the more than 5,000 dealers worldwide. Since production began back in 1990, only about 1,500 engines (out of 1 million produced) had been returned to Romeo and only in about 10% of these returned engines could Romeo's quality assurance personnel confirm the defect reported by the customer.

The RQP goal of satisfying customers' expectations required departments to respond to every quality problem reported by a customer, including internal customers. Quality problems were logged onto a complaint form and Action Plans had to be prepared in response to the complaints. For example, since machining's customers were engine assembly operations, an engine assembly team could reject an engine coming from machining and issue a complaint form. The machining department then had to prepare an Action Plan within 24 hours in response. The Action Plan had to identify the source of the problem, how machining planned to solve it, and how machining planned to prevent it from recurring. Quality problems originating from outside the plant or quality problems of a critical nature required immediate, not 24 hour, responses. Weekly quality meetings chaired by quality personnel reviewed complaint forms and corresponding Action Plans filed over the past week. Action Plans that had not been fully implemented were highlighted for special attention.

But the RQP process began long before production began. Production team members worked closely with product and manufacturing engineers on the design of parts and production processes. The plant-floor employees knew, from first-hand experience, what could and would go wrong with particular designs or processes. The goal was to influence the design of the engine parts and

associated production processes to yield high quality, "producible" engines. Chris Hineman, Plant Controller, explained how these relationships had begun to payoff:

The close working relationships between our line people and our engineers is one reason we have had the most successful launches in Powertrain's history.

New Vehicle Quality Surveys were used to benchmark Romeo's engines against other Powertrain engines and against the engines used in competitor's luxury cars. Romeo's two engine launches (in 1991 and in 1993) had the best quality rating among all Powertrain engines. The quality ratings in Romeo's 4.6 liter engines were approaching worldwide best-in-class levels.

None of the excellent results in the quality of internal processes and finished engines could have been achieved without a substantial investment in education and training of all employees. The newly-rehired REP employees had created a Life Education Center by renovating a deserted building located behind the main production facility. The Life Education Center operated from 2:00 - 4:00 P.M. every weekday, offering courses ranging from high school equivalency to graduate level technical and management skills. The operating committee taught four courses that were required for all employees: Mission/Team Concept, Quality 101, Team Problem Solving, and Productivity 101. Each employee had to complete a minimum of 300 hours of training.

Work Team Organization

Romeo assigned work teams to production areas that corresponded to a major engine component or assembly operation. Romeo's managers had established a work team organization because they believed that team work was essential to being able to produce, with consistently high quality, the complex 4.6 liter engines. The teams were designed to include people who needed to work together and who could learn from each other. Many of the processes at Romeo were fully automated so that fewer people were required to supervise machines than if an individual worker were assigned to each machine (the common practice in traditional machining operations). The team members were not to be machine operators; they were to use their specific expertise to continuously improve production and quality processes. Team members performed tool checks, quality checks, and problem solving. Chris Hineman summarized how the work team organization at Romeo was fundamentally different from the organization of other engine plants in the Powertrain division:

When George [Pfeil] asked me to come to Romeo as controller, we decided to do things differently. From the beginning we told our people, "The machines build the parts. The machines are designed to run automatically. Your job is to think, to problem solve, to ensure quality, not to watch the parts go by."

Each of the 13 work teams operated as a separate business unit, with its own team manager, and its own support staff, including engineering, maintenance and administration. Work teams were given the authority, information, resources, and training needed to make decisions and implement them. They operated and maintained their own facilities which included work spaces, locker rooms and meeting rooms. Teams were responsible for safety, quality, engineering, productivity improvements, and maintenance of equipment. No housekeeping department existed at REP; each work team cleaned its own area.

Barriers to flexible work assignments had been eliminated. Romeo had only 11 labor and 2 skilled trades classifications, a sharp contrast with other Ford Motor Company Powertrain plants that had more than 200 labor classifications and at least 8 skilled trades classifications. The traditional barriers between laborers and management had also come down. All employees (including George Pfeil) wore the same Romeo Team Work Uniform, with a shirt patch embroidered with the individual's first name serving as an employee's only identification.

Management wanted to encourage initiative, creativity, and prudent risk taking in the work teams to support growth in capabilities and continuous improvement. George Pfeil believed that "failure based on prudent risk should not be punished, but should be treated as part of the learning

experience." Rich Carter, hourly mechanical coordinator for the C line work team in engine assembly, described Romeo's learning and risk-taking environment:

At Romeo, we do what the teams decide. George [Pfeil] wants team managers and coordinators to support the team's decision, even if we feel it's wrong, until they get it right. We can stop a decision if it is too costly to implement. But, if we stop a decision, then we have to give a reason and an alternative.

Everybody cares about failing, but we do not make a big deal of it. We do not finger point if a wrong decision has been made. We are a team. If we fail, we fail together. If we succeed, we succeed together. We agree that a decision is our decision and we all live with the consequences.

Carter described the autonomy and responsibility vested in team members:

I see all my people as managers who can influence their production environment. When we get a new part to produce or an existing part has changed, I guarantee that the new part does not go into production until my people sign off on it. They have to commit to its production. They examine the process and must agree that it can be done. If they do not like the new part then they tell me. They give suggestions and alternatives to improve the part.

Work team members recognized and appreciated the differences in Romeo's work team environment relative to the other production environments where they had worked:

In the old production environment, we were not always asked to contribute suggestions. The foreman told us what to do and sometimes it was done even if it was wrong. Here at Romeo, the team decides what to do. Now our voices are heard. All middle management has been cut out, foremen, superintendents, and general superintendents. Management relies on us, the team members, to make decisions. Salary people help us make these decisions; the production and manufacturing engineers work for us. They are always saying, "We work for you. What do you need." And, they listen to us.

Sam Nammo, machine operator on the connecting rod team, described his commitment to the team organization at Romeo:

I came to Romeo in December of 1990 with the option of returning to my former plant whenever I wanted. I will never go back. I drive 60 miles each way to work at Romeo.

Chris Hineman provided his perspective on the Romeo work environment:

In traditional factories, the financial system viewed people as variable costs. If you had a production problem you sent people home to reduce your variable costs. Here, we do not send people home. At Romeo, people are viewed as problem solvers, not variable costs.

Information Systems

A vast investment and deployment of information technology resources were essential for Romeo's work team and quality processes. REP had 5 Digital Equipment Corporation VAX computers to process information about machines, test parts, and disseminate information about processes and parts to more than 400 pagers and approximately 350 personal computers in the plant. The software for these computers had been developed mainly for Romeo applications.

The most important of the real time systems was the *Machine Monitoring System (MMS)*. This system signaled when a defective piece had been made or when a machine had stopped. Machines were laid out along long rows. A neon marquee hung from the ceiling between each pair of machines. When machines were operating normally, a green light appeared on the marquee. Thus a single operator could look down a long row of unmanned machines and verify that all were functioning normally. If a machine stopped, either because materials had become jammed or because a defective part had been detected by the automatic gauging equipment, the signal light for that machine would change from green to red, and the marquee would display the status of the machine and a fault code indicating the reason for the shutdown. Simultaneously, this information was also sent to the VAX cluster to record the time of the stoppage, the machine ID number, and the fault code. The computer immediately sent an automatic page to the operator assigned to that machine cluster, signaling that a failure had occurred, the machine ID, and the fault code.

The Paging System

The paging system was used extensively for communicating inside the plant. Each day between 12,000 and 16,000 pages were placed, 60-70% were machine generated to page an operator when a machine had unexpectedly stopped working. In addition, if the computer sensed that significant repairs would be needed, it would also send a page to a skilled trades person. The team manager would be paged if the machine had previously been identified as a critical or bottleneck resource. If the machine was not restored to running condition within 30 minutes of the work stoppage, then the plant manager would be automatically paged.

In addition to these automatic pages sent after a machine failure, each team manager and area manager could program the system to automatically send a page every hour and report critical information. For example, an area manager concerned with output through a critical process could receive an hourly page that reported the production quantity through that process during the preceding hour. Also the paging system could be used to facilitate authorization of purchase or maintenance by team managers. Someone needing authorization could send the request to an area or team manager via the paging system and the manager could reply using one of the 350 terminals located throughout the plant.

Ren Falzon, an hourly maintenance coordinator on the engine assembly team, explained how the MMS and paging systems saved time and allowed him to focus on productivity issues:

In a regular plant I would be running all over the floor just trying to gather the information that the MMS and paging systems provide. With this information already provided and with the improved communications, I have more time to devote to quality planning, productivity group meetings, and team meetings. Instead of running around the plant floor putting out fires, I now have time for preventive, long-term strategic planning to solve our maintenance problems.

Use of the Information Systems

Every employee had been trained on the MMS and had easy access to the system via one of the 350 computer terminals distributed about the plant. Employees could query MMS to obtain the time of a particular breakdown and the code for its cause. Employees obtained, from MMS, summaries of the number of occurrences and the time lost per occurrence by fault code. This information could be viewed in real time or accumulated for daily, weekly and monthly tracking.

Ken Bernek, a machine operator on the connecting rod team, explained the usefulness of the MMS system to him:

When a machine breaks down, we do not have to stand around and guess at what had gone wrong. The fault codes tells us what is wrong. So, we can focus

our attention on the problem and solve it quickly. In my old plant when a machine stopped running, there would be three managers standing around guessing at what the problem was. And none of them would know for sure what the problem was. Here, we work with the facts provided by MMS. This information is very accurate and reliable.

Rich Carter gave his perspective on the usefulness of MMS:

MMS focuses our discussions. For example, when we started producing the four valve engines, we had a problem on the C line. Everyone in the assembly area was sure that the C3 operation was causing the problem, because this operation is very labor intensive. We looked at MMS and discovered that we were down twice as much on the C1 operation. Without MMS we just have opinions, with MMS we work from facts.

Team members concurred that the daily information from MMS was the most informative and actionable:

The best information we get are the fault codes from MMS. MMS helps us to focus our efforts. Without it, we would not know where to start. For example, the bottleneck analysis determines which operation is the bottleneck. We then go to the Pareto fault charts to see what problems are creating downtime there and start a problem-solving team to fix them. The team takes some actions and we watch if the trend on that fault code starts to go down. Then we could put our priorities on another problem.

Bottleneck Operations

George Pfeil wanted the teams to focus their efforts on improving operations at bottleneck machines and processes. He believed, "Unless you are improving your bottleneck operations, you are not improving machine efficiency." Pfeil's philosophy had been implemented in the design of MMS by having the system prepare a report to help the work teams identify the operations that were currently the bottlenecks in their area. The teams also received a report from MMS that ranked the causes for shutdowns at the bottleneck. This Pareto analysis encouraged problem-solving teams to concentrate on the principal causes for shutdowns on critical resources.

Lonnie Prater, an Area Production Manager, concurred with this focus on bottleneck resources:

The plant is manned thinly. We must focus our resources on the bottleneck operations in each area. Everyone knows which is the current bottleneck operation. If it goes down, everyone runs over to solve the problem.

The teams tracked trends in downtime caused by fault codes to verify that their approaches were indeed fixing the problem and reducing downtime on the bottleneck resource. Prater met daily with the problem-solving teams to learn about their progress in reducing and eliminating recurring faults with machines. The teams had been taught that if they were successful in improving bottleneck processes, then the bottleneck process should move to the next constraining process in the department. Prater recalled:

We formed a small problem-solving team five months ago for one bottleneck operation that was producing only 105 pieces per hour on a machine that had an ideal rated capacity of 200 pieces per hour. The output soon improved to 160 pieces per hour. Frequently, however, the improvement in capability outstrips machine output because the bottleneck will have shifted.

Scrap

Anytime a defect was detected in a part, an employee filled out a red tag form to record the causal factor for the defect. The employee attached the form to the part and also entered the defect information into the nearest computer terminal. The computer removed the item from inventory and, from this information, produced daily, weekly, and monthly scrap reports for each team. Summary scrap reports could be prepared by fault code and by part. A weekly meeting discussed the trends and principal causes for scrap and defective material at the plant. As with monitoring throughput, the teams performed Pareto analysis on the defect causes and generally concentrated on attacking the top-3 causes. As needed, teams solicited information from suppliers and product engineering. At the weekly meetings, teams reviewed 8-D reports designed to guide their analysis of defect causes.¹

If a consistent pattern of problems could be traced to supplier defects, the labor and overhead that had accumulated until the defect was detected was billed back to the supplier. A monthly quality meeting at the plant, at which both internal (Powertrain) and outside suppliers could be invited to participate, discussed major unsolved problems.

The Checkbook System

Each team received an authorization for how much they could spend on indirect materials such as supplies, tools, scrap, and maintenance material. The authorization was calculated based on the number of parts produced each day. Spending on these items had been placed under the direct control of the team. Each day the team could see the authorization they had generated, based on that day's production, as well as the requisitions they had.

The authorization rate for indirect materials was based on a targeted overhead allowance for each area derived from the budgeted overhead per engine specified by the Romeo controller's office. The long-run goal was to continually reduce overhead spending per unit of output. Prater was proud that the plant's teams had beaten the initial spending goal for the 4.6 liter engine by \$30 per engine, but acknowledged that sometimes teams over-spent their allowance:

The authorization operates more like a charge card with a nominal daily limit than an actual checkbook that you could not over-draft.

Several teams attempted to lower expenses by negotiating directly with suppliers for their indirect materials. Prater recalled that some teams discovered they could get discounts if they bought a high quantity of certain supplies. Subsequently, if the production part changed or a production problem was solved, the demand for these supplies was greatly reduced, and the team got charged for the excess inventory. Area managers tried not to intervene in these local decisions, feeling that, in the long run, it was better for the teams to take responsibility for and learn from such experiences than to expect management to check and approve each of their decisions.

Teams also received a weekly report on the total overhead expenses charged to their department, including telephone, utilities, indirect labor, and salaries of engineering and technical assistants. Dick James, the financial analysis team manager, noted that the Romeo system assigned to areas and teams many expenses that were sometimes considered "fixed" costs by other plants.

¹ The eight disciplines employed to analyze and fix defect causes were: (1) identifying the team members responsible for the analyses; (2) providing a concern description; identifying (3) containment actions, (4) root cause(s), and (5) corrective actions; implementing the (6) permanent corrective actions and (7) actions to prevent recurrence; and finally, (8) congratulating the team members.

The teams are responsible for their own expenses. They are billed for everything, including power, water, and telephone. If they leave the lights on, their costs go up.

Romeo's managers wanted to have their teams see the cost of having salaried employees, like process engineers and technical assistants, available to perform tasks in the team's area. The managers encouraged teams to make suggestions that would influence the use of salaried people. For example, teams could ask salaried people for help in increasing productivity or to use less overtime. Teams also had the option to not replace salaried people who left due to retirement or attrition.

Members of the teams were not completely sure how to use the financial information they were now seeing for the first time.

The checkbook helps us keep track of our spending against our target but it is a little difficult for everyone to relate to these numbers. The machine operators, in particular, don't have any feeling about whether or not we are making our target. About the cost reports, the numbers are there and we have to understand them but they're not really useful. We're focusing now on productivity improvements; perhaps in the future we might concentrate more on cost analysis to reduce tooling costs.

Weekly Meeting

Each week, George Pfeil met on a rotating basis with one of the departmental teams to discuss opportunities for improvement. Wendy Coscia, the connecting rod team manager, described her team's weekly meetings:

In our weekly meetings, we focus on quality, productivity, and scrap. George Pfeil allows us to focus on these instead of variances. He recognizes that the old-style weekly variance meetings were negative discussions about spending too much. Here, we focus on ways to spend wisely to improve quality and productivity.

If our discussion indicates that there is a recurring machine problem or quality issue, I ask for volunteers to form a small problem solving team to resolve the issue. If the issue is a concern for both shifts, then we set up a common problem solving team with members from each shift. I have found that my team members like to get involved; they like to have a voice; and they are willing to take ownership of the problem solving process.

Unit Costs versus Labor & Overhead Reporting

Historically, Ford's Powertrain plants relied on an extensive reporting system that compared actual labor and overhead expenses, by account, to budgeted amounts.² Dick James commented:

We believe that the Labor and Overhead report is sometimes contrary to the continuous improvement philosophy we operate under at Romeo. The trend of actual costs is a better indicator. Cost is a result of all the other actions we do at the plant; it's a sanity check, not the driver.

² The Labor & Overhead reporting system is described in Peoria Engine Plant (A), HBS Case # 9-193-082.

The Labor and Overhead (L&OH) reporting system was fresh in area manager Bill Yowan's mind since he had only recently transferred to Romeo from another Powertrain plant:

The L&OH system was a tremendously time consuming process to track budgets and variances. I spent 30-45 minutes each day learning about what happened yesterday so that I could respond to questions in this report. Also, when you encountered problems, you began to do all types of things to get back within your budget. Some of these were counter-productive. The pressure was to stay within budget not to identify what had gone wrong and attempt to improve it.

Lonnie Prater concurred with his colleague:

Problems were revealed but, because of budget constraints, you sometimes delayed taking corrective action. In order to accomplish something permanent you had to circumvent the system. You spent the money where you knew it was needed but it took 6-7 months to begin to get the payback in lower costs. Meanwhile you made up excuses to explain the variances.

Yowan described how his behavior changed after assignment to the REP:

*At Romeo, I spend my time **improving** actions, not **tracking** actions. Instead of focusing on how much my area spent yesterday on tooling and overhead, I am coaching and problem-solving with teams on how to enhance line productivity. Though, to be honest, I am still not completely comfortable with this new environment. I keep thinking that I might be challenged at any time to respond to a query from the division, from people outside the Romeo world, about how much was spent on the last shift.*

Chris Hineman described his experiences with the Labor & Overhead system:

In a traditionally organized plant, people focus on the variance percentage, the percent deviation of actual cost from budget or standard. They soon learn that there are two ways to avoid unfavorable variances: reduce actual costs or increase your budgets. Initially people work hard to reduce costs, but at some point the demanding improvement factors and the lack of investment capital prevent a manager from achieving the budgeted costs. A manager then develops a case and argues for an increased budget allowance because of product design, mix changes, economics and machine deterioration. The increased allowances might be agreed to but how has this process helped to reduce spending in the plant?

Costs have to go up with volume and down with volume, with unit costs constantly improving. With a budget system we concentrate too much on complexity and volume shifts, and look for excuses to explain away any increase in costs.

Recently, however, the Romeo plant had started to produce a new 4-valve aluminum block engine in addition to the much simpler 2-valve cast iron engine. Some of the managers wondered how actual cost reductions could be accomplished when a much more complex engine was introduced into the plant.

Exhibit 1

