Figure 11.3a. INDUSTRIAL PROBLEM SOLVING: The Role of Variation

This video is about continuous improvement in quality and productivity in the auto industry; a major theme is that an essential component of quality is *reduced part-to-part variation*. The video illustrates this theme by an investigation at the Ford Batavia Transaxle Plant that compared the performance of the *same* automatic transmission, particularly the *valve body* (the control unit which makes the transmission shift gears), manufactured in North America and in Japan.

Bear in mind the following matters as you watch the video:

- The comments of the individuals in the video provide insights of importance into pervasive problems facing many North American industries; however, the viewer should note the maxim: *it's simple but it isn't easy* with respect to both understanding a problem and implementing its solution.
- The *complexity* of the casting of the aluminum outer casing of the valve body; this is a useful reminder of the level of sophistication that can be achieved in mass production of consumer goods.
- The meanings of three technical terms:
  - *microfinish* refers to the microscopic smoothness of a surface, usually of a metal part;
  - *runout* is departure from roundness or circularity, usually of a bore, shaft, piston, etc.;
  - *tolerance* is the difference (or 'distance') between the upper and lower (engineering) specification limits.
- The method of measuring the *inside* diameter of a (circular) hole.
- The diagrams of repair frequencies (a histogram), of timing valve surface finish variation (distributions), and of the percentage of tolerance used (distributions).

Highlights of the video's printed and spoken presentations are as follows:

* The Ford Motor Company is committed to never ending quality progress through such approaches as continuous reduction in process variation. This presentation describes the importance of that philosophy by comparing a Ford designed transaxle manufactured by a Ford plant and by an off-shore source (sometimes referred to in this presentation as "the competition").
* The analysis of their product indicates that piece-to-piece consistency is now the name of the game in quality – it is now what you have to do to be competitive in the world market in the area of quality.
  ○ Quality no longer is make it to blueprint or specification – quality is never-ending improvement.
* Although the recent investigation that we completed at Batavia was a limited 10-piece investigation, we feel that the information we gained was very valuable in that it was an apples-to-apples comparison between the two groups of transmissions.

Jim Bakken, Vice President – Operations Staffs

* The Ford Motor Company's operating philosophy is to produce goods and services that meet customer needs and expectations by providing an environment that encourages all employees to pursue continuous improvement in quality and productivity throughout the company, its supply base, and in the dealer organizations. In the past, we have developed the idea that the attainment of 100% quality goal was the attainment of making every part within engineering specifications; when we had done that, we had achieved the ultimate. Progress could no longer be considered continuous. This is changing. A new concept provides the opportunity for us to pursue continuous improvement in quality and productivity when we recognize that improving the variation of critical characteristics in products or in processes leads to quality improvement – it truly does – and that's what the videotape you are about to see is all about: the reduction in variation and how it contributes to continuous improvement in quality and productivity.

John Betti, Vice President – Powertrain and Chassis Operations.

* Over the past few years, all of us in the automotive business have experienced some real shocks. A lot of the truths that we had accepted with little or no question have been challenged, and many of them haven't stood up under rigorous (and, in some cases, not so rigorous) analysis. The tough competition we faced has caused us to rethink some of the basics of the business. For me personally, the results of the investigation .... at the Batavia Transaxle Plant destroyed one of the basic truths about the business that I had accepted long ago: .... building parts to print isn't good enough. For most of us in the technical and manufacturing end of the business, one of our big struggles has been to get parts to print or the find a way of getting, or giving, a deviation to cover the parts being produced. Never in the 31 years I've been in this business have I ever been asked, or have I ever asked, to tighten the tolerance.
* Everybody knows that the engineer asks for tolerances twice as tight as he needs because chances are the manufacturing guy will build it to print only part of the time at best. When I took over Powertrain and Chassis Operations a little over 4 years ago, my quality objective was to make sure we were building everything to print or to make sure that we had an authorized engineering deviation. In some of the plants, I couldn't even find out if we were building to print. What Ron and his team learned is that while we've been making great progress in meeting my original objective of building to print, our not-so-friendly competition was making great strides in building uniform parts – every part just like the part ahead of it and just like the part following, with very little variation. While we were arguing about how good the parts had to be,

(*continued overleaf*)

they were working hard on making them all the same. We worried about specifications, they worried about uniformity. While we were satisfied and proud if we were to print, and then worried about keeping it to print, they started with the part to print and worked on continuous improvement in the uniformity of the parts. Control, uniformity, continuous improvement.

∗ Ron will give you a specific example of how the superior uniformity on the parts of our competitor, particularly the valve body, significantly improved the function of the product we gave the customer. I am absolutely convinced that they have a superior approach. Think of the significant improvements we could make in fits, function, cost, weight, in virtually every aspect of our product, if we could be assured that every part was an exact copy or with very little variation. I am personally committed to this approach. If we are to be competitive, we must start with processes under statistical control, and dedicate ourselves to continuous improvement in the uniformity of the parts being produced. I'm sure that when you've heard Ron's story, you too will be convinced that it can and it must be done.

Ronald Coosaia, Batavia Plant Manager

∗ Historically in our business, we've always said it is our responsibility in the plant to make things to blueprint, to specification, to gauges, to acceptance standards, to deviations, and that was the quality philosophy we built Batavia around, and we think we did a pretty good job to start with on making it to print, and making it to specification, and making it to test stand parameters.

Drexel Bunch, Quality Control Manager

∗ The quality of the ATX transmission, as measured by conformance to blueprint, has been excellent since our launch. We since have learned, however, that quality as measured by our customers is dependent on less piece-to-piece variation in the assemblies. That is key to the performance of an automatic transmission.

∗ Piece-to-piece variation in these valves and the bores within the body of the main control is critical and it must be maintained in a very tight tolerance; the less variation there is between piece to piece, the more consistently the transmission will perform.

∗ Batavia is unique in that we face off directly with foreign competition making the exact same transmission that is made at Batavia. We learned from very early experience with customers that they accepted the transmission made by the foreign competition better than ours. We set out to find out why. We procured a small sample of transmissions and tore them down and analysed them for quality, again as measured in conformance to blueprint. It was discovered during that analysis that they also had better quality as measured in piece-to-piece variation, a significant point, explaining again why their transmission was accepted as performing better than the Batavia-produced ATX transmission. Conformance to blueprint was excellent, conformance to blueprint of the Batavia transmission is excellent but more piece-to-piece variation is observed.

Bo Westerkamp, Quality Control Supervisor

∗ The evaluation that we did here at Batavia was an in-depth evaluation. We took 10 Batavia transmissions and 10 competitor's transmissions and, from the point that we got them in the door, we did every analysis that was possible. The first thing we did was to put the complete assembly across the final test stands, get numerous printouts. Secondly, we tore the transmissions down, took all bolt torques, completely visualled the transmissions, tested all subassemblies before they were disassembled; then, after that, we disassembled all the subassemblies and completely did dimensional checks on all the variable measurements that we could make.

Drexel Bunch, Quality Control Manager

∗ We knew our competition was tough but we weren't sure just how tough; the study showed we were good but it showed they were damn good.

∗ The transmissions function one like the other; this lack of variation comes through in customer acceptance and what they perceive to be as quality.

Ronald Coosaia, Batavia Plant Manager

∗ Their contamination levels are lower than ours, you see very few chips and burrs, very few nicks, and significantly better microfinishes in both the functional and the non-functional areas of our product.

Jerry Priest, Quality Control Superintendent

∗ There was one particular part that we looked at, the valve body, and we were checking an inside diameter of a bore. I had a floor inspector making the checks, and as he went to the job and began to use the gauge, which is a very sensitive air-electronic piece of equipment, he put the first off-shore unit on and, as he gauged the part, it showed right on the low limit of the gauge. As he rotated the part to look for runout, he found none. After several more checks he was getting the exact same reading on each part, so he stopped gauging and got his gauge masters out to verify that the gauge was working correctly. It was mastered correctly so he resumed his checks again and all 10 pieces checked in the exact same place with absolutely no runout and no variation, which just seemed amazing. He thought the gauge was broken and called in a request for a gauge repairman who came out and verified that the gauge was indeed working and that the quality level of

Figure 11.3a. INDUSTRIAL PROBLEM SOLVING: The Role of Variation (continued 1)

that part that was indicated in the checks was indeed true.

∗ The variation was so small that it could not be measured by these sophisticated instruments.

Ronald Coosaia, Batavia Plant Manager

∗ You try to determine what causes that consistency so you take your competition's valve body apart and you measure some things – you measure the size of the bore and you record it, you measure the size of the valve and you record it, and you measure spring loads; you also measure microfinish. And on the 10 competitive units that we looked at, we discovered that our competition uses about 27% of the tolerance for all those components that I described: springs, bore, microfinish, size of the valve and size of the bore. Now that piece-to-piece consistency allows that valve body to function more consistently when it gets in the test stand and the result when it gets in the customer's car.

∗ We did the same thing for Batavia – a wider spread, indicating we had some things to do. It indicated to us that on our valves we used 70% of the tolerance; now that's significantly higher than I would have imagined, and the kind of processing equipment we have in Batavia would indicate that we could do much better and we are working on it and are getting better. And we're in the process now of going through a complete analysis of our grinding process, and working with our spring suppliers, so that we can get the kind of consistency that our competition has. Then, once we achieve that consistency, we can manage our product – our competition manages the product – .... to make bores on the high side, valves on the low side, have mean dimensions on the springs, and we'll get as good a functioning main control in test, and in what our custo- mer sees, as our competition does.

Bo Westerkamp, Quality Control Supervisor

∗ I guess the bottom line that we learned at Batavia is that meeting blueprint is not good enough.

Having viewed the video, you should recognize an important idea we have encountered previously in this Part: in the third set of comments by Ronald Coosaia (given above on this page), we are reminded there is seldom an easy route to process improvement; rather, a sustained and systematic effort to identify and then remove causes of unwanted variation (or other problems) is usually needed. As Box and Bisgaard point out on the overleaf side of Figure 11.4 with reference to the Matsushita take-over of an American television manufacturing plant just outside Chicago: *It took four or five years of meticulously weeding out the causes of defects.*

- Of central importance in this context is the fact that statistical methods offer a *planned approach* to this type of problem solving, in contrast to the widespread misconception that problem solving mostly is a 'hit-or-miss' affair; the statistical approach (*e.g.*, using the FDEAC cycle) usually is substantially more efficient, and the *Analsis* step is commonly based initially on what are known as Ishikawa's *Seven Tools*:
  - Check sheets for data collection;
  - cause-and-effect diagrams;
  - stratification charts;
  - control charts.
  - Pareto analysis
  - histograms;
  - scatter diagrams;

  We have previously discussed histograms (in Part 3) and scatter diagrams (in Part 9); the other five tools will be described later in this Part 11.

Two further matters are:

- The video illustrates the key role of data collection of (often difficult) measurements in industrial problem solving.
  - It also makes clear the importance of collecting the *right* data (answering the *right* Question) and ensuring that the data are of adequate precision and adequate accuracy in the Question context.
- It is our individual experience that it typically costs *more* to purchase an item of *high* quality than to buy the same item of *low* quality; however, Deming (and others) have emphasized that this can be a *misleading* analogy for industry – increased quality of output resulting from process improvement can lead to *in*creased productivity.

1 For the *Ford Batavia* video presentation, identify each of the following and give a brief description of it:
- the *problem* – the *Question* to be answered;
- the *solution* of the problem – the *Answer* to the Question;
- the *cause(s)* of the problem;
- the *implementation* of the solution.
  - Explain briefly the importance of considering the matter under these four headings.

2 The second comment by Bo Westerkamp (given above near the middle of this page 11.13) is a summary of the lesson(s) from the investigation at the Ford Batavia Transaxle Plant; explain briefly whether his statement conveys the essentials of the Investigation's findings.

3 Outline what is meant by the statement [near the middle of the first side (page 11.11) of this Figure 11.3a]: *quality is never-ending improvement.*

(*continued overleaf*)

4 Near the end of his comments [near the top of the second side (page 11.12) of this Figure 11.3a], John Betti says: .... *we must start with processes under statistical control* .... .

- Explain briefly what is meant by a process that is *under statistical control*.
- Account briefly for the requirement for statistical control in the context of John Betti's remarks.

5 In the third of his first set of comments [on the lower half of the second side (page 11.12) of this Figure 11.3a], Drexel Bunch refers to .... *a small sample of transmissions* .... .

- What was the actual sample size? Explain briefly.
- What were the advantage(s) of the *small* sample size? Explain briefly.
- What are the (potential) *dis*advantage(s) of a *small* sample size? Explain briefly.

6 What are the *measurement* implications of the situation described by Jerry Priest [starting at the bottom of the second side (page 11.12) of this Figure 11.3a]. Explain briefly.

7 What are the statistical *danger(s)* of the evaluation procedure as it is described by Bo Westerkamp [on the second side (page 11.12) of this Figure 11.3a]? Explain briefly.

8 Outline what Ronald Coosaia is refering to [towards the bottom of the second side (page 11.12) of this Figure 11.3a] when he mentions .... *contamination levels* .... .

9 In his third set of comments [given on the third side (page 11.13) of this Figure 11.3a], Ronald Coosaia notes that the 'competition' used substantially less (*e.g.*, 27% *vs* 70%) of the tolerance than was used at Ford Batavia prior to the investigation described in the video. In addition to more consistent performance, what *other* advantage does the lower percentage confer? Explain briefly. [You may wish to refer back to Example 5.17.4 of the STAT 220 Course Materials in formulating your answer.]

10 In his third set of comments [given on the third side (page 11.13) of this Figure 11.3a], Ronald Coosaia outlines a method for obtaining more consistent functioning of the valve body: .... *bores on the high side, valves on the low side, have mean dimensions on the springs* ....; explain briefly how this suggestion would lead to the desired result.

11 The theme of the importance in industry of reduced variation has arisen in (at least) two Figures in earlier Parts of these Course Materials: Figure 2.10 about the Maple Leaf gold coins, and Figure 6.2 describing Program 18 in *Against All Odds: The Sample Average and Control Charts*, where, about 16½ minutes into the video (*i.e.*, about 15½ minutes into its actual *contents*), Anthony Gallonio, the Frito Lay Quality Assurance Manager, comments about packaging potato chips: .... *our variation from bag to bag diminished; we've probably made a 50% improvement in variation since we've instituted SPC in our operation.*

- Identify the factors in each situation (*viz.* Ford, the coins, Frito Lay) for which reduced variation is of concern.
- Compare and contrast the advantage(s) of reduced variation in the three cases.

12 In Program 18 of *Against All Odds: The Sample Average and Control Charts*, just under 16 minutes into the video (*i.e.*, just under 15 minutes into its actual *contents*), as a lead-in to Anthony Gallonio's comments about packaging potato chips (mentioned above in Question 11), it is stated that: *In the past, a company would inspect the product at the end of the process, but that's a little late to know if something's wrong.*

- Briefly indicate what is *wrong* with inspection of the finished product as a method of quality control.
  - What *alternative* to final inspection is advocated in the *Ford Batavia* video (and in Program 18 of *Against All Odds*)? Indicate briefly the way(s) in which this alternative is an improvement.

13 In the comments near the bottom of the third side (page 11.13) of this Figure 11.3a, the point is made that increasing quality *by process improvement* also increases productivity. Suggest way(s) of increasing quality that would be likely to *decrease* productivity; explain briefly in each case.