The Great Nuclear Fizzle at Old Babcock &Wilcox

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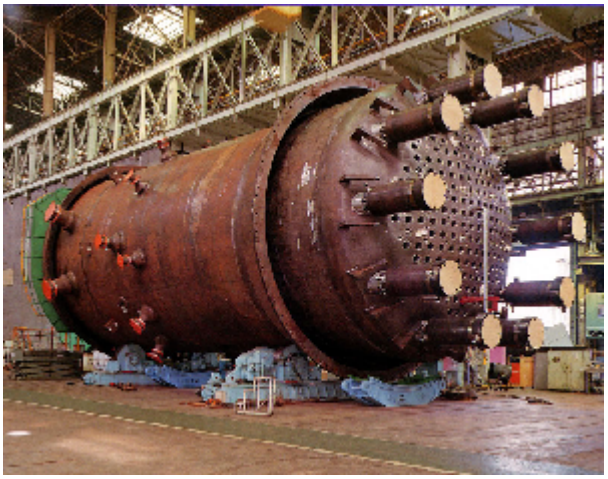
Everything went wrong when the venerable boilermakers turned to building pressure vessels for atomic reactors. The whole electric-power industry felt the consequences.

The long awaited transition for the U.S. electric-power industry into the nuclear age has been slowed by a number of factors, including technological difficulties and public resistance. But a specific and unexpected cause for delay has been one company's crucial failure to deliver a single vital component of nuclear power plants. The failure, basically, was a management failure, and on a scale that would be cause for concern even in a fly-by-night newcomer to the nuclear industry. The company, however, was no newcomer. It was proud old Babcock & Wilcox Co., a pioneer of the steam generating business, whose boilers were used in one of the first central power plants ever built (in Philadelphia, in 1881). Babcock & Wilcox had an impressive $648 million in sales last year, making it 157th on FORTUNE's list of 500 largest industrials, and it has been engaged in nuclear work in a major way for fifteen years, producing, among other things, atomic power systems for Navy submarines.

Moreover, the corporation is one of only five that are engaged in building nuclear power plants in the United States. With consumption of electricity growing by nearly 10 percent a year, the utilities are counting heavily on the new nuclear stations to avoid brownouts and power failures in the years ahead. Poor performance at Babcock & Wilcox is thus one of those problems that could send ripples through the whole economy. All of B & W's troubles involve a single product: nuclear pressure vessels. These are the huge steel pots - some are more than seventy feet long and weigh more than 700 tons - that contain atomic reactions. They must meet rigid specifications set by the Atomic Energy Commission, and B & W built a $25 million plant at Mount Vernon, Indiana, just to fabricate them. Sure that the Mount Vernon plant would operate as planned, B & W sold its entire projected output of pressure vessels for years ahead. But nothing seemed to go right at Mount Vernon. Plagued by labor shortages and malfunctioning machines, the plant produced just three pressure vessels in its first three years of operation. Late in 1968, after the production snarl reached horrendous proportions, a vice president responsible for the Mount Vernon operation committed suicide in a bizarre fashion.

Last May, B&W was forced to make a humiliating disclosure. Every one of the 28 nuclear pressure vessels then in the Mount Vernon Works was behind schedule, by as much as 17 months. For the utility industry, the news from B&W meant intolerable delays in bringing 28 badly needed nuclear plants into service, with all the added expense and problems that would be entailed. Philadelphia Electric Co. estimated that it would have to spend an extra $50,000 a day just to provide from other sources, such as high-cost gas turbines, the power that it had counted on getting from its delayed nuclear units.



Typical Nuclear Pressure Vessel

CREATING ITS OWN COMPETITION

With so much at stake, B&W's customers could not well afford to be patient. Twenty-one of the pressure vessels tied up in Mount Vernon Works were there on subcontracts from the two giants of the nuclear industry, General Electric and Westinghouse Electric. Both companies swiftly took the almost unprecedented step of forcing B&W to turn most of their partially completed vessels over to other manufacturers. When B&W, in an ill-conceived gambit, tried to hang onto two of the transferred vessels, Westinghouse took the case to court and won. In all, 14 G.E. and Westinghouse vessels - perhaps $40 million worth - were taken out of B&W's shops. Some of the firms that got the business had never made a pressure vessel before for use in a U.S. reactor; B&W had managed to create hungry new competitors in its own line of work. Only four G.E. and three Westinghouse vessels remain at Mount Vernon.

The company itself has barely begun to pay the high price of failure. Its earnings last year were still a robust $2.04 a share. In the first six months of this year, losses associated with nuclear work pushed earnings down to 22 cents a share - not even enough to cover the 34-cent quarterly dividend. From a 1969 high of 40.5 last January, Babcock & Wilcox stock has sagged into the low 20s. At that price, the stock is hovering around book value.

The man in the middle of all these troubles is President George G. Zipf (pronounced Ziff), 49, a low-key executive who started with B&W in 1942 as a metallurgical engineer. But the man who bears the main

onus of responsibility is Zipf's predecessor, Chairman Morris Nielson, 65, who chose Zipf for his present job a year ago, and handed him his present problems.

IN TROUBLE DOWN BY THE OHIO

"All areas of the company were profitable in 1968 with the exception of atomic energy," President George P. Zipf told Babcock & Wilcox stockholders, after taking over as chief executive officer from Chairman Morris Neilson in September 1968. Up to then, losses on nuclear work had never seemed particularly troublesome. They were regarded simply as the price of B&W's ticket into the atomic age - and B&W had been getting into, and prospering in, new technologies for a hundred years.

But one segment of its nuclear venture has driven B&W into deep trouble. The plant that it built along the Ohio River at Mount Vernon, Indiana, to produce huge steel pressure vessels for atomic reactors, failed to function as expected, with all kinds of dire results. One especially unhappy result was that B&W had to give up some partially completed pressure vessels to competitors.

BAD BOY FROM BLAIR, NEBRASKA

Neilson is a flamboyant leader, a big bluff man with bright blue eyes and a full head of gray-blond hair, who has a gift for salty language. More than one secretary quit "Doc" Neilson's employ because of his profanity, and more than one executive suffered a colorful tongue-lashing in the chairman's office.

Nielson got his nickname by virtue of being a doctor's son in Blair, Nebraska, where he was known as "Young Doc." That was as close to earning an academic degree as Neilson came. As a boy, he himself has said, he was "incorrigible" and was kicked out of school "for being a bad influence on the rest of the students." He then enrolled in a Lincoln, Nebraska, high school and worked part-time as an embalmer. "I got into trouble in Lincoln, too," Neilson told an interviewer a few years ago. "One night, I came home with my nose over and under my eye. I'd been in a fight and got hit with a pair of pliers. I woke up my old man and he looked at my nose, and said, "You're going to look like a goddamn syphilitic the rest of your life." My old man used to tell me that there were two steps ahead of me - first reform school and then the pen."

Instead, Young Doc became a steeplejack and iron-worker and in 1924 joined the corporation he was later to head. "I came to B&W by accident," Neilson has recalled. "I was working at American Bridge as an iron-monger on a job in Chicago, and another fellow and I got drunk. We got on the train and got off at Des Moines. We were walking past this construction job, and a fellow slid down a column and said, "You looking for work?' We figured we were." It was a B&W job, erecting boilers for central station power plants, and from the start Doc Neilson felt at home in the two-fisted company. "Those construction workers were goddamn rough people. They were hard drinkers, fighters, and lived by their wits."

By the time World War II came along, Neilson was superintendent of marine erection. He supervised the installation of B&W boilers in 4,100 Navy and merchant-marine ships during the war. Later he headed the entire boiler division, including manufacturing, and in 1957 became president and chief executive officer.

When Nielson took charge of B&W the company was already deeply involved in nuclear work. Neilson's predecessor, Alfred Iddles, had recognized early that B&W would have to prepare for the day when the atom would challenge fossil fuels as a source of energy for central generating plants. Under Iddles, B&W attracted an outstanding stable of nuclear scientists and engineers and, in 1956, set up an extensive research facility at Lynchburg, Virginia. One of B&W's first important nuclear jobs was to build Consolidated Edison's Indiana Point Plant. Another project was the reactor for the nuclear ship Savannah. B&W lost money on these jobs, but it gained experience needed to secure a corporate toehold in the nuclear era.

Nuclear losses continued under Neilson, but he improved B&W's over-all profitability dramatically. Iddles had run the company as a looseknit grouping of semiautonomous subsidiaries. Neilson centralized and systematized management. Every executive's areas of responsibility and authority were carefully spelled out in manuals that defined company policies and aims in all sectors of the business. Although sales stayed near or below the 1958 figure of $366 million until 1963. At that point, sales also began to go up, rising 71 percent in the next five years. Profits peaked in 1967 at $33 million, at $2.69 a share (compared to $1.05 a share in Nielson's first full year).

In view of his critics, who have lately become numerous, the seeds of B&W's present problems were planted in the years of Neilson's rich harvests. It can be seen, in retrospect, that he may have been too successful in keeping B&W lean. His determination to keep down the fat sometimes "had the effect of cutting into good red meat" says a former B&W executive. Experienced managers found themselves stretched too thin to cover all their areas of responsibility. Worse, they did not always feel that their authority matched their responsibility, (i.e., men in the field were held responsible for results they did not have the power to bring about).

The most biting criticism of Nielson's regime comes from men charged with nuclear assignments. In their eyes, Nielson's lack of formal education proved a serious handicap. Explains one former B&W executive: "Nielson

created an atmosphere in which engineers and technical people just didn't feel at home. Their ideas were not treated with respect. They felt that top management didn't understand technical problems, and didn't trust those who could understand them."

A TOUCH OF CORPORATE ARROGANCE

From the start, B&W had foreseen a long wait before its nuclear work became profitable. Developing the necessary skills and technologies to compete in the nuclear industry has proved to be a slow and expensive process for every company that has tried it, including G.E. and Westinghouse. But what B&W had not expected was to lose money on its Mount Vernon Works. When the plant was planned in the early 1960's, Neilson appeared to believe that he had found a niche in the nuclear industry that offered a quick return. A nuclear pressure vessel, though huge and manufactured to demanding technical standards, is essentially just the kind of heavy steel unit that B&W was accustomed to fabricating with ease.

While the Mount Vernon plant was under construction, U.S. utilities went on a nuclear-plant buying spree, starting in 1965. At the time, the surge in orders seemed like a lucky break for B&W. The Mount Vernon plant was designed to produce one completed pressure vessel a month, once it was in full operation, and there had been considerable doubt during the planning stages "if we'd ever get enough work to fill the place," a former B&W executive recalls. Orders for pressure vessels poured in, faster than anyone had predicted, and the Mount Vernon plant soon got loaded up with work. It is now clear that management made too little provision for the time it would take to get the new plant operating at full capacity. Says one B&W customer: "I think you have to say that corporate arrogance was involved."

The first delays at Mount Vernon were caused by suppliers falling far behind schedule in providing vital equipment. A linear accelerator, used to detect welding flaws, was not delivered until August 1966, 11 months late. Even worse, a highly automated, tape-controlled machine center - the heart of the plant as originally conceived - arrived a full year behind schedule, in September 1967.

THE LURE OF UNSPOILED LABOR

By then, the plant had been operating on a makeshift basis for almost two years. And it had already become apparent that B&W's century of demonstrated competence in the fabrication of heavy steel products had not protected the company from grievous error. A principal one was the site itself - a corn field near the little farm town of Mount Vernon (population: 6,200) in southwestern Indiana. The location had been chosen mainly because of its position on the Ohio River, safely above any known flood level, and yet reliably accessible for deep water barges. This was an important advantage because nuclear pressure vessels are so immense that they can best be transported by water. B&W had owned the land for a number of years, and had set up a small plant there for making boiler parts.

Pressure Vessel During Transport

What Mount Vernon did not have was a pool of skilled labor. This was a serious drawback because the AEC, for safety reasons, sets rigid standards for machine work and welding on nuclear projects. Late last year, a company memorandum reviewing the Mount Vernon fiasco observed: "Production workers required a new level of knowledge, intelligence, and judgement to operate the machinery, perform operations, and maintain the very high quality standards." At the outset, however, B&W took an optimistic view of its prospects - choosing, according to that 1968 memorandum, to regard Mount Vernon as "an unspoiled labor market." Presumably, the company expected to find a more tractable group of workers there than it had at Barberton, Ohio, where B&W's power-generated division had had its headquarters and principal manufacturing facilities for many years.

The company planned to overcome the obvious shortcomings of Mount Vernon's labor pool in two ways. First, through automation - using that sophisticated machining center - and second, through a massive training program that would entice farmers away from their cornfields and quickly turn them into skilled welders and machinists. In one year, B&W spent $1 million just to train welders. But almost as fast as men reached the levels of skill required, they left B&W for jobs elsewhere. On September 30, 1968, only 514 of the 1,560 hourly employees hired in the preceding three years were still working for B&W; in other words, the company had trained three men for each one it retained. "Turnover of the Mount Vernon workforce has been a particularly frustrating problem, and a major reason B&W has been unable to bring its full manufacturing capabilities to bear

on the situation," the 1968 memorandum concluded. Some potential workers proved to be untrainable, others had a "general negative attitude" toward heavy industry, and "some were not able to adjust, and therefore returned to their farms."

"IT DROVE US OUT OF OUR MINDS"

Workers who remained with B&W did not prove to be as unspoiled as the company had hoped. Even before the pressure vessel plant opened, it was organized by the Boilermakers Union (which also represents B&W workers at Barberton) amid charges of unfair labor practices against the management. The plant was closed by labor disputes on several occasions. The most serious occurred when the three-year contract expired in 1967, while equipment was still being installed. The Boilermakers went on strike over wages and work rules, and the plant was down for forty days - unnecessarily long, in the view of President Thomas Ayers of Chicago's Commonwealth Edison, who had pressure vessels tied up at Mount Vernon.

From the standpoint of production, Nielson won a victory that amounted to overkill. Under the new contract, wages remained too low to stem the flow of workers away from B&W or to attract qualified workers from other areas. The B&W memo cites the "non-competitiveness of our wage scale" as a reason for the high turnover rate in the Mount Vernon workforce. Even for experienced workers, welding two pieces of eight-inch steel together is a demanding task, particularly in nuclear work, in which each weld is examined by X ray. When an imperfection is found, the weld must be "mined out" and done over again. In most plants, less than 10 percent of the welds must be reworked, and a rework of less than 1 percent is sometimes achieved. But at Mount Vernon 70 percent or more of the welds were rejected on being inspected. "It drove us out of our damned minds," recalls Ayers. "So costly! So time-consuming!" Ayers and other B&W customers say that they urged the company to increase the supervisory force - which regularly worked one and a half to two shifts daily -- so that a closer watch could be kept on the welds as they were built up.

In addition to its problems, B&W ran into unexpected trouble with equipment. The linear accelerator for X-raying welds was installed in mid-1966 but did not go into full operation until a year later. The tape-controlled machining center was even more of a headache, and began functioning as planned only a few months ago. In this center, huge vessel segments are positioned on optically aligned ways, and then moved a distance of 250 feet, while a series of precise machining operations are performed simultaneously, controlled by computer-prepared tape. The concept was a good one, since nuclear pressure vessels are custom jobs, each tailored to a customer's specifications. But "debugging" of the machinery proved unexpectedly difficult. One problem was that the plant was not air-conditioned, and temperature changes threw off the many delicate adjustments that had to be made. In addition, an earthquake - fairly rare in Indiana - shook up the plant last year and it took nearly a week to reset the machine tools. Other start-up difficulties were simply incomprehensible. For example, a vital boring mill was put out of operation for several weeks when a tool broke. There was no spare on hand.

Engineering support was another problem. Most of the engineers assigned to Mount Vernon actually worked in Barberton. Moreover, their duties were split between Barberton projects and Mount Vernon projects.

Technical Note

Nuclear pressure vessels are designed and built to order for a specific installation. Each component is uniques. They are then shop assembled into sub-assemblies and eventually into the final unit.

By contrast, conventional boilers are made from standard or semi-standard components, manufactured and shipped in pieces, then assembled on site.

Boiler tubes, where George Zipf had gained his experience, are even more repetitive than conventional boilers. They consist of simple steel tubing that is cut and bent. Only specific dimension vary. A particular boiler may have hundreds of identical tubes. This can simplify both production and scheduling.

DEATH IN A DRY BATHTUB

The man directly responsible for the Mount Vernon plant was John Paul Craven, vice president in charge of the power generation division at Barberton. As head of B&W's largest division, Craven was No. 3 man in the company, and was paid $87,000 a year. At one time, there was speculation in the company that Craven might someday become president. A gentle, upright bachelor of 60, Craven was tall and distinguished-looking. An engineer by training, he had been with B&W all his working life, and he had no interests outside his job. For a while, Craven had raised roses as a hobby, but after he was made vice president he gave up roses in order to devote himself more fully to B&W. "His work was his whole life," says an old friend.

As the bottleneck at Mount Vernon grew worse, Craven came to feel that neither his customers nor corporate headquarters in New York fully appreciated the difficulties of Mount Vernon's advanced machine tools. Nor did he believe that he was given the authority, the budget, or the personnel that he needed to fulfill the

plant's commitments. Says another of Craven's old friends: "Paul couldn't bear to sit in Barberton and have all the shots called from New York - and then be expected to take responsibility for not producing."

In September of 1968, before the seriousness of the pressure-vessel crisis at Mount Vernon became generally known, Nielson stepped aside as chief executive in favor of George Zipf. For a man destined for the top at B&W, Zipf had an unusual background. All of his predecessors had been identified with boilers, but Zipf came from B&W's tubular-products division at Beaver Falls, Pennsylvania, near Pittsburgh. This division, whose work is more akin to steel manufacturing than boilermaking, produces tubing for B&W's own use and for sale to other industrial customers; it accounts for roughly 30 percent of B&W's total sales, and more than half its profits. When he transferred to New York as executive vice president in 1966, Zipf had been at Beaver Falls for twenty years, ever since graduating from Lehigh University. He was a stranger to the problems of the power-generation division, and to that division's big corporate customers.

Less than a month after taking over as chief executive from Nielson, Zipf scheduled a meeting at the Mount Vernon plant with Craven and Austin Fragomen, vice president for manufacturing. The meeting was set for a Monday morning. During the preceding weekend Craven told friends that for the first time in his life he thought his job was getting beyond him. Sometime on the Sunday afternoon or evening before his scheduled meeting with Zipf, Craven took off his clothes and climbed into a dry bathtub in his $250-a-month apartment at Akron's luxurious Carlton House. Then he slashed his ankles, cut his throat, and stabbed himself in the heart with the serrated eight-inch blade of a butcher's knife.

After Craven's death, George Zipf took personal charge of the power-generation division, and of the Mount Vernon works in particular. Before long, both Austin Fragomen and the Mount Vernon plant manager, Norman Wagner, resigned. That left Zipf free to put a whole new team to work on the company's pressure-vessel debacle.

THE CHAIRMAN SELLS SOME STOCK

Beginning in 1967, both GE and Westinghouse, along with many of the utilities that were the ultimate customers for B&W pressure vessels, repeatedly expressed worry over the Mount Vernon plant's faltering operations. In the fall of 1968, B&W pacified GE to some extent by setting up a temporary welding shop on barges anchored at Madison, Indiana, where expert welders from the Louisville, Kentucky, labor pool could be obtained. But for the most part, B&W management continued to maintain that its optimistic scheduling, with some minor changes, would prove to be realistic.

Some utility executives who met with Zipf to express their concern left with the conviction that he did not appreciate just how serious the pressure vessel delays had become. On some occasions, he seemed to regard his callers as bothersome intruders. "He just sat there like a damned Buddha," reported one customer after such a meeting.

Faced with such frustration, GE and Westinghouse began to consider the drastic step of pulling some of their delayed pressure vessels out of the overloaded Mount Vernon Shops. Both companies assigned teams to scout for other manufacturers that might be able to take over B&W vessels and complete them. There were not many potential candidates. Up to then, B&W and Combustion Engineering, Inc. had pretty much divided the U.S. pressure vessel business between them. Combustion Engineering had managed to keep close to schedule on its deliveries, and had been expanding its Chattanooga machine shops. It had unused capacity. In addition, Chicago Bridge & Iron Co., which had previously done only on-site fabrication, was setting up a pressure vessel plant in Memphis. (On-site fabrication is a more expensive method of constructing pressure vessels, used only when it is extremely difficult to transport the massive units to a site intact.) The GE and Westinghouse teams also looked abroad for companies that might be able to take over some of the work.

In April, while B&W's biggest customers were searching for other suppliers, Doc Nielson - who was retiring on May 1 as an officer of the company, but keeping the title chairman - quietly sold 15,000 of his 20,000 shares of B&W stock. The price at the time was about $33 a share. A couple of weeks later B&W stockholders got their first official hint of serious trouble ahead. George Zipf revealed at the annual meeting that he expected earnings to drop 20 to 30 percent in 1969 because of the company's losses on nuclear business. (The actual decline, of course, has since proved to be much greater than Zipf predicted.) Before long, the price of B&W's stock sank into the 20s.

A QUICK TRIP TO COURT

On May 14, less than a month after the annual meeting, B&W sent out telegrams brusquely letting customers know that the situation at Mount Vernon was even worse than they had suspected. Zipf and his new team had completed a gloomy reevaluation of the plant's capabilities, and B&W was adding two to twelve months to earlier delivery schedules, some of which had already been stretched past the dates called for in B&W's original contracts.

On receiving this news, both GE and Westinghouse sought B&W's cooperation in transferring vessels to the other shops that they had scouted out. B&W agreed to subcontract some of its work to these plants. But an

unexpected difficulty soon arose. Westinghouse had determined that Rotterdam Dockyard Co., a major shipbuilding and steel fabricating firm in the Netherlands could take two vessels and improve on the B&W schedule - provided that the vessels were transferred promptly. Westinghouse located space on a ship that would be calling at New Orleans on the desired date and, by paying a premium, was able to arrange for the ship to cancel calls at other ports and proceed directly to the Netherlands. B&W agreed to put the two pressure vessels on barges and start them on their way to New Orleans, while it negotiated a subcontract with Rotterdam dockyard. But negotiations broke down when B&W and Rotterdam could not come to terms. To the horror of Westinghouse officials, B&W ordered the barges back to Mount Vernon.

Westinghouse then decided to pay B&W for the work it had already done, and take over the vessels itself. But speed was required. If the barges did not continue down the river while these new arrangements were made they would miss the ship to Rotterdam. Now Westinghouse found itself at a strange impasse - it could not reach anyone at B&W who could rescind the order for the barges to return to Mount Vernon. Nielson was "not available." Zipf was "out of the country." Frustrated in its effort to reach top management and work out an amicable settlement, Westinghouse reluctantly went into U.S. district court in Pittsburgh, and won a temporary restraining order to prevent B&W from taking the vessels back to Mount Vernon.

During the hearing, Federal Judge Wallace S. Gourley had a revealing exchange with John T. Black, B&W's manager for commercial nuclear components.

Judge Gourley: On this contract for $2,542,000, what would you say that you expect to make on this?

Black: This specific contract?

Judge Gourley: Yes.

Black: I don't expect to make a profit.

Judge Gourley: You don't expect to make a profit?

Black: No, sir.

Judge Gourley: I don't know why you would want the material to work on. You are not in business to lose money for your stockholders.

Black: We do not expect to make it.

Judge Gourley: In other words, on this contract (for) $2,542,000, you don't expect to make a penny profit for your corporation, if you went ahead and finished it?

Black: No, sir.

Judge Gourley: How much on this other one (for) $2,304,789. What profit could you be reasonable expected to make on this contract, if you finished it?

Black: I would think that one probably (is) in the same condition.

Judge Gourley: If you went ahead and finished this, you wouldn't make a cent?

Black: I think on direct cost, we would cover our direct cost to labor and shop expenses.

Judge Gourley: I meant after everything, would you or would you not make any money on this?

Black: No.

Judge Gourley: I wouldn't think your stockholders would want you to finish. I certainly wouldn't.

BACK ON TRACK

After Westinghouse won possession of the two pressure vessels and sent them off to Rotterdam, B&W raised no further objections to transferring work out of its shop. Indeed, it actively cooperated with its customers to get the job done. Westinghouse sent five vessels to Combustion Engineering's Chattanooga shops and two to a French firm, Societe des Forges et Ateliers du Creusot. General Electric turned three vessels over to Chicago Bridge & Iron and had B&W send two others to Japan's Ishikawajima-Harima Heavy Industries. In every case, these firms are expected to equal or better the delivery dates set in May by B&W.

With the load at Mount Vernon lightened, prospects look better for the fourteen pressure vessels that remain there, including seven for nuclear plants that B&W itself is building. For example, the Sacramento Municipal Utility District has been notified that the vessel for its Rancho Seco nuclear plant, a B&W project, will be only a couple of months late, instead of the year that seemed likely in May. That means that the vessel for Sacramento is essentially on schedule again, since the delays now expected are no more than could be accounted for by the labor disputes and earthquake that Mount Vernon suffered.

To his utility customers, George Zipf remains very much a man on trial. But now that their pressure vessels are moving along again, some utility executives are convinced that he has quietly managed to put B&W back on the track. One move that has met their approval was the appointment in September of an experienced Westinghouse man as vice president in charge of the power generation division - John Paul Craven's old job. Bringing in an outsider at such a level is something new for B&W, and one B&W customer believes that he knows what it means: "I think George Zipf is really in command now." If this is so, he will have a lot to do to restore the honored old name of Babcock & Wilcox to its former luster.

Teaching Notes

This case is most useful in group discussion. The facilitator should ask the questions below and guide the discussion.

1. What happened?

The objectives of this question are to establish a timeline of major events, ensure that everyone understands the way events unfolded and to open the session on a neutral and non-threatening note.

Point out to participants that we are interested only in bare facts. Discourage any analysis or opinions. Simply prepare on a flip chart a chronological sequence of events with approximate dates.

2. What went wrong?

With this question you will get a long list of wide-ranging errors, mistakes, accidents and misjudgments. Let this discussion go on for some time until there are 10-20 items on the list. Then point out to the participants several characteristics of their list:

- This is a very long list of errors, mistakes and misjudgments.
- It covers a very wide range of business and technical issues from personnel and labor to plant location and technology.
- B&W had been in business for over 100 years. They had been very successful and were one of the most respected firms in their industry. How could they have made so many mistakes in so many different areas? (Pause) Why did this all happen at the same time? Why did these weaknesses in decision-making not show up years or decades before? (Pause).

Now, redirect the discussion with some more structured questions:

3. How are the nuclear pressure vessel and boiler customers the same? How are they different?

Here we focus on the customers, their attitudes and requirements. There should be minimal discussion of the products themselves.

One issue here is the question of who is the customer? For new boilers, the primary customer is the utility or boat-builder with a secondary customer as the consulting engineering firm. For boiler tubes, the customer is the simply the owner as represented by their maintenance department.

For nuclear vessels, this question is more complex. There is the contractor for the power plant and the utility but there are also regulatory officials who must be satisfied.

Develop two parallel lists showing the similarities and differences.

4. What did the customers want? Why did they contract with B&W rather than some other firm?

This question establishes the customer needs and the "Order-Winning Criteria." It shows the reasons customers contracted with B&W. Prepare ***two ranked lists*** of order-winning criteria, one for each class of customer. Your list might look something like this:

Boilers

1. Price
2. Delivery Speed
3. Basic Quality

Boilers and replacement tubes are much more of a commodity than nuclear vessels.and price is likely to be the primary consideration.

Delivery speed is often important, especially for boiler tubes because they are replacement items and need to be available when a boiler is shut down for maintenance.

Basic quality is a given. Quality standards for boilers are long established and all firms in this business must pretty well meet them in order to be in the market.

Nuclear Vessels

1. Quality as conformance to specifications for testing and inspection.
2. Delivery Reliability
3. Reputation (Perceived Capability)

Quality is absolutely the #1 consideration in nuclear vessels because of the regulatory environment. At the same time, it is more difficult because of the uniqueness of the pressure vessels and because it cannot be readily inspected. Moreover, rework is disastrous. Finally, quality is somewhat different in nuclear. Quality means following the procedures and using qualified personnel for welding. It is not just the result that counts but how the result was obtained.

Delivery reliability is different than delivery speed. Reliability means you will have it when promised. With nuclear plants, lead times are very long because of the planning and scale of construction. However, once the delivery date is established, any delays are disastrous for the entire project.

Price may be of some consideration in nuclear but only if it greatly exceeds the project budgets or is far greater than competitor's prices.

Reputation is a key element because of the difficulty in comparing potential supplier on their abilities to produce quality as defined in the nuclear business and their delivery reliability.

5. How is the *process* of making nuclear pressure vessels and boilers the same? How is the *process* different?

Similarities:

- Steel Fabrication
- Welding

Differences:

- Standardization
- Repetitiveness
- Flow Vs Batch & Queue
- Skill Levels Required

Point out to participants that the similarities are superficial and the differences much more fundamental.

6. If B&W had done this analysis and kept the results in mind, would they have made the same decisions? For example:

- Would they have located the nuclear operation in a low labor cost but low skilled area?
- Would they have paid the lowest labor rates in that area?
- Would they have selected a machining technology that was labor efficient but but proven?
- Would they have located engineering support in a distant city?
- Would they have used the same engineers and organization in both nuclear and boiler operations?

It is useful to go back to the original list from Question 2 for this review. In most instances, the answer is that they would have made different decisions.

7. What were the Key Manufacturing Tasks for the Nuclear and Boiler operations?

Take the participants back to the list of Question 4. Remind them that this list is the Order-Winning Criteria; the things customers need most. These give rise to the "Key Manufacturing Tasks"; i.e., those one or two tasks that manufacturing must perform extraordinarily well at to satisfy their customers.

8. Could the two operations have been performed in the same factory using:

- **The same people**
- **The same equipment**
- **The same scheduling system**
- **The same engineering skills**
- **The same organization structure**
- **The same quality approach**
- **The same managers**

Of course, the answers are "NO". Primarily because the customers and their needs are different. But, also, because the processes are different. This means that almost everything in the manufacturing system must be different.

Key Manufacturing Tasks

Wickham Skinner's research suggests that a particular factory can excel with no more than one or two overall objectives. These might be quality, delivery reliability, response time, low cost, customization, short life cycle products, or another competitive dimension.

The Key Manufacturing Task(s) is the most important thing the factory must do or achieve for success. Terry Hill, in his book "Manufacturing Strategy" shows how to identify the Key Manufacturing Task(s) and link it to marketing and corporate strategies.

The Focused Factory

A Focused Factory strives for a narrow range of products, customers and processes. The result is a factory that is smaller, simpler and totally focused on one or two Key Manufacturing Tasks.

Conclusion

This case study illustrates some of the reasons why Manufacturing Strategy is so critical for success. There is much more to the Manufacturing Strategy approach than just Key Manufacturing Tasks and Focused Factories.

The case study also illustrates why attempts at copying Toyota's Manufacturing Strategy (Toyota Production System or Lean Manufacturing) is a dangerous business.