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Curb on tweaking made Intel strong

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IT seemed like a smart idea at the time: speeding up the silicon wafers, from which semiconductors are made, as they moved from one station to another on an Intel Corp. manufacturing line. But the result was unexpected: More defective chips came off the line.

The puzzled plant engineers looked for the problem. Finally, they realized what had gone wrong. The temperature of the wafers changed between stations, and the speedier trip meant that they were arriving at a slightly different temperature than before—and that the slight variance from the norm was leading to flaws. It was a costly lesson, but an important one.

Engineers love to tweak the system, to make things run better. But at Intel, manufacturing plant engineers must restrain themselves. That seemingly unnatural self-control is a key part of what Intel calls "Copy Exactly," a system that stands out as one of the company's competitive advantages—and may help explain why Intel is such a juggernaut.

Copy Exactly stems from the 1980s, says Sunlin Chou, an Intel vice president and director of components technology development. He and other executives at the time—including Craig Barrett, now the company's president—faced tough times back then. Too many defective chips were emerging from Intel factories. Customers insisted that Intel help "second-source" competitors by licensing chip designs to other companies, thus ensuring customers an adequate supply of chips. Intel wanted to reduce defects and keep all of its customers' business.

The cost of new chip-making plants was soaring, meanwhile. Discovering a major problem once a plant was in full production was looking less and less affordable.

Copy Exactly and its corollaries were the solution. The system begins with the design of a new chip. Intel doesn't just make sure the chip will work. It also makes sure the production process will work reliably.

The only way to do this is to literally build a fabrication plant as part of the research and development process, and to include people from all over the company in the process. It's not as large as the ones that ultimately create most of the new chips, but still quite big—and its success ensures that the company can make the processors in sufficient quantities to meet demand. To pull this off, Intel brings in people from the manufacturing area, not just R&D, to work together at every step of the way.

This isn't cheap, but it's much less expensive than trying to fix the process once the big factories are running. The idea, Chou says, was to add risk earlier in the process and reduce it later. When a new fabrication plant costs several billion dollars, a figure that rises with each new generation of chips, the financial price of failure at later steps is unacceptable.

When the full-fledged plants do go into production, the processes and assembly lines are as close to identical as possible. Small differences can cause big problems.

This system also creates what Intel likes to call its virtual factory. This organizational structure says that anyone in any of Intel's plants making, say, Pentium chips—whether in California, Singapore or anywhere else—is actually working in one gigantic global manufacturing factory. A clean-room production worker in a Santa Clara plant is part of a team that includes someone doing the same job in another building on another continent.

The fundamental idea is that each facility should produce chips at almost precisely the same rate, with the same (hopefully declining) rate of defects. People in the same jobs at different factories will learn together, and put their ideas into production together. Predictability is essential. So people don't tinker with the system except after spirited debate combined with minute examination of the data, pro and con.

"Say that someone here has a great idea," says Frank McCabe, manager of the Intel complex in Liexlip, Ireland. "We bring it to our colleagues" and decide as a team whether every plant—or none—should use it in production.

"The plant managers, as a team, manage all of those fabs," he says.

One way to make this system work is to reward people for using other people's ideas. In applying for an internal prize, called the Intel Quality Award, one key element was "to show processes we copied from innovators in other plants," McCabe says.

There's no arguing with results. Chou produces a chart he titles "Reducing risks faster," on which one axis shows chip defects and the other shows time. "We never got to the desired level of defects in the old days," he says. But the chart shows that in recent years the defect level was at an acceptable level the day the plants started production, a huge change.

G. Dan Hutcheson, president of VLSI Research Inc. in San Jose, has studied the Copy Exactly system and calls it a big win for Intel. Before Copy Exactly, he says, Intel's customers were more in control because they could demand that Intel provide its technology to other companies so as to have a second source for semiconductors. Afterward, Hutcheson says, Intel was able to persuade customers that its multiple factories were better than a second source.

Intel's power stems from more than Copy Exactly, of course. Its take-no-prisoners style with competitors and customers alike is legendary, if occasionally excessive. Its consumer marketing, meanwhile, has been enormously successful.

But Copy Exactly is a remarkable story in its own right. When historians look back at the growth of the semiconductor business, they'll undoubtedly note the irony that some of the smartest engineers in the world held their tweaking instincts in check—and in the process helped propel their company and industry forward. ❑
