A customer surveys, RELIABILITY FACTORS IN STEEL USAGE

Extracted from a paper
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In this atomic age there is a growing need for better steel. There are about 50 million grains in 1 cu in. of steel which has a grain size of no. 5. Each of these individual grains has a composition of atoms; it has boundaries and is in a certain relation to its neighboring grains. I have no comment to make about the basic atoms because, try as we will, we can't change them when we make steel. The problem seems to lie in what we put in the grains—how we make them—how we make assemblies of these grains in ingots, casting, forgings, or rolled shapes.

While a small iron whisker has a tensile strength of 2 million psi, just why are we so inefficient that common steel has about 100,000 psi tensile—5 pct of the potential of pure iron? When we take into account a factor of safety of say five, we get a design value of 20,000 psi or about 1 pct of the 2 million psi.

But times have changed and the steel hasn't—at least not very much! We no longer can afford to use the great weight or mass and the unnecessary size that goes with great mass. One hundred years ago the solution to a problem on a railroad was to make the section heavier and use more material and whatever space was needed. Costs were low, labor cheap, speeds slow, and competition was quite leisurely. And we were still fighting the Indians!!

Today, with the cold war, extremely high costs of everything—especially labor—unbelievably keen world-wide competition, and with speeds getting up to those required for space travel, we're forced to do a complete about-face in our ideas on the use of mass and volume. In our latest designs we can no longer *play it safe* because if we do, we won't live!

We're rapidly being forced to use to a greater proportion the potential properties of metals. Weaknesses are now appearing, because we've changed the rules of the game. What used to be acceptable in performance simply won't do the job of today. In other words, we demand a degree of reliability that is sufficiently high so that our assemblies will do the job required. If we have 100 components in our assembly, and each component comes from a lot that is 99 pct ok (1 out of 100 defective), then we only get 36 pct good assemblies. Change the component reliability to 98 pct instead of 99 pct and only 13 pct of the assemblies will work—96 pct decreases the assembly performance to 1.6 pct! Or go the other way—if 410 parts of an assembly each come from lots that are 99.44/100 pct reliable, only one out of 10 of the resulting assemblies will satisfactorily perform!

In order to cope with this new way of life we have become extremely suspicious and critical of any lot

of steel. Each lot of incoming material is checked in great detail. We can't live with seams, cracks, pits, porosity, pipes, inclusions, variable grain size, poor annealing, decarb, woody structure, high hydrogen content, and poor susceptibility to plating. We keep complete, detailed inspection and performance records of every lot of steel received.

The very dramatic increases in the specifications of our latest high-strength fasteners have been brought about by the most exacting attention being paid to each element in which there could be a variation—and this variation minimized. The critical areas of the present generation of missiles are now held together with tension threaded fasteners that have a minimum strength of 260,000 psi, with an elongation of more than 10 pct. Our newest types of planes also require these high-reliability fasteners. We are now about to introduce a 300,000 psi threaded fastener with a fatigue strength that has a proportional increase with the tensile value. This is double the strength of the 125,000 psi bolts of 10 years ago. But 2 million psi is the ultimate aim, and we're now marketing 300,000 psi. Give us a little time in the future, and we'll be a lot higher! But to do these things, each of the 50 million grains in each cubic inch of steel must be right!

In addition to this need for higher strength materials, we are constantly being pressed for higher reliability. Take the case of the Atlas Intercontinental ballistic missile, reputed to have 300,000 separate components. What must be the average reliability of each of these parts—assuming all are vital to success—in order to put the Atlas on target nine times out of ten—not too high a goal in this day of sudden-death warfare. Well, each part has to have a reliability for the mission of 99.99996 pct! Here even Ivory soap purity fails us. If the Atlas' 300,000 parts each had a reliability of only 99.44/100 pct, they would never get a single missile to the mark. The resulting overall reliability would be an infinitesimal fraction—a decimal point followed by 731 zeroes and then a 2!

The recent 12-month warranty on our new automobiles is going to make a great change in our way of life. Cracked nuts on engine connecting rod bolts—for a saving of 10¢ per 1000 units—will not be a good investment for anyone connected with the deal—the steel supplier, the manufacturer of the nuts, the purchasing agent, the receiving inspection department, or the company who would dare to put such a shoddy end product in the hands of the public.

I encourage you to give some thought to the steel you make and realize that one way or another it must be better tomorrow than it is today. Highly reliable steel is the only kind we can afford to buy because that's the only kind we can live with. Just 50 million good grains in each cubic inch of steel!

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