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THE NEVER-ENDING CHALLENGE

by

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Progress--like freedom--is desired by nearly all men, but not all understand that both come at a cost. Whenever society advances--be it in culture and education or science and technology--there is a rise in the requirements that must be met in all fields of human endeavor. The price of progress is acceptance of these more exacting standards of performance and relinquishment of familiar habits and conventions rendered obsolete because they no longer meet the new standards.

My remarks today concern the harmful results that follow when industry fails to live up to the exacting standards of a new science--reactor technology. We depend on private industry to supply the materials and equipments for our nuclear power plants. Current industrial practices are, on the whole, not geared to the standards imposed by this new technology.

While it has not been too difficult to focus management attention on the nuclear reactor itself, which represents a novel development, it has been extremely difficult to get management to give effective attention to the conventional components of these plants. Routine manufacturing and engineering practices continue to be followed, even though experience has shown these practices to be inadequate.

Successful operation of a nuclear power plant depends on the reliability of all its parts, the reactor as well as the conventional components--the heat exchangers, pressure vessels, valves, turbo-generators, etc. Although these are all designed and manufactured by long established procedures and so should present no special difficulty, delivery and performance of these conventional items have been less reliable than of the nuclear reactors themselves. Compared with the complexity of nuclear engineering itself these problems individually are minor in nature, yet they occur so frequently as to require a disproportionate amount of our time. If we are to build successful nuclear power plants at reasonable cost and in reasonable time, the whole plateau of industrial workmanship, engineering inspection, and quality control must be raised well above the present level. This is the responsibility of management. Management's technical function, after all, is to see to it that production meets the customer's requirements.

When management fails to do so the **benefits** our nation obtains from huge investments in research and development are reduced. Of an annual total of about \$16 billion, nearly \$12 billion come out of the taxpayer's pocket. The size of these expenditures places a great responsibility on industry. It must get people into management who have the competence to make certain that stockholders and taxpayers receive full value for the money invested in new technology, and that the nation's technical resources are effectively used. Yet, time and again I have found that management is reluctant to depart from outdated practices; that it is not informed of what is actually going on in the plant; that it fails to

provide the informed and strong leadership necessary to bring about improvements in engineering and production. It is not well enough understood that conventional components of advanced systems must necessarily meet higher standards. Yet it should be obvious that failures that would be trivial if they occurred in a conventional application will have serious consequences in a nuclear plant because here radioactivity is involved. Even in the non-nuclear parts of our plants we must have full reliability if the great endurance of nuclear power is to be realized.

I should like to discuss two areas that are in need of continuous and painstaking attention to detail by management, by engineers, and by workmen. These are: incomplete understanding of basic manufacturing and inspection processes, and poor workmanship and poor quality control. Let me give you specific examples:

1. Incomplete understanding of basic manufacturing and inspection processes. When we design components for nuclear power plants we make every effort to utilize existing processes. At first we assumed basic processes that have been in widespread industrial use for many years would be well understood. Our experience showed this was not so. Here is an example of the type of difficulties we constantly encounter.

There are 99 carbon steel welds in one particular nuclear plant steam system. The manufacturer stated that all these welds were radiographed and met specifications. Our own re-evaluation of these welds--using correct procedures and proper X-ray sensitivity--showed however that only ten percent met ASME standards; 35 percent had defects

definitely in excess of ASME standards and the remaining 55 percent had such a rough external surface that the radiographs obtained could not be interpreted with any degree of assurance. We found this condition of unsatisfactory welds and improper radiography to be quite prevalent in many segments of industry. When we insisted that manufacturers meet the standards which had been established for many years as being necessary, very high rejection rates for welds resulted. One manufacturer, over a three month period, had to reject 47 percent of all carbon steel welds made in his shop; his rejection rate for welds made in the field, where conditions were less favorable, was even higher. In other types of welds a manufacturer had 85 to 100 percent rejection rates. I would like to emphasize that this unsatisfactory welding situation came to light only because we demanded that manufacturers prove to us they were meeting the standards which they themselves had accepted in the contract.

Casting is another basic process that is not fully understood. We often have to order two to three times as many castings as we need, because we have so much trouble obtaining satisfactory ones. Otherwise we may not have enough acceptable castings on time. When we do receive acceptable castings, this is only after 200 to 300 weld repairs have been made on each casting. Although this sort of difficulty has existed for many years, industry has not yet developed adequate techniques for successfully producing large castings.

Radiography is another basic process of contemporary conventional technology where we are constantly troubled with problems. Extensive use of radiography for over 30 years led us to believe that this nondestructive

sting technique for determining soundness of welds and castings was well understood, and that the sensitivity requirements of existing ASME and Navy specifications were being met. We found this definitely not to be so. For years many of these requirements have been consistently violated. In consequence, large numbers of radiographs were of little or no value for determining integrity of welds and castings.

Besides this unsatisfactory situation in welding, casting and radiography, practical application of nuclear power is also hampered by unresolved problems of fatigue in materials.

Present knowledge of material fatigue under thermal cycling stress is meager. In consequence, we in the reactor group have had to develop special test loops to conduct tests for determining the adequacy of conventional components. Based on results of these tests we have had to change the design of many equipments--valves, nozzles, thermal sleeves--all of which have been in use by industry for many years. Yet fatigue is not peculiar to nuclear propulsion; nor is it a new problem for industry. The Civil Aeronautics Board reports that every year several commercial airplane accidents are caused by fatigue failure of propellers, landing gear, or hydraulic pressure lines. Reporting on a recent helicopter accident caused by fatigue cracking of a main rotor blade, the CAB warned that there was urgent need for better understanding of safe fatigue life of materials and for more conservative design.

2. Poor workmanship and poor quality control. Modern technology--in nuclear power, in high speed aeronautics, or in high performance computers--requires greater excellence in workmanship and in quality control than has

been necessary in the past, and this even in the conventional components used in these advanced systems. This is particularly true for nuclear technology where hazards of radioactivity and difficulty of access for maintenance and repair require workmanship and quality control to be at a much higher level than in normal industrial applications. In the case of submarines, moreover, the crew lives and works between two dangerous environments--the intense sea pressure outside the hull of the ship, and the hot, high pressure primary and secondary systems of the propulsion plant. If the boundaries of either of these pressure containments should fail, serious consequences would result. The reason why I emphasize and insist on design excellence and high quality workmanship is that our nuclear submarines have to operate submerged for long periods of time, even under the polar ice cap where it may not be possible to come to the surface.

Recently we discovered that a stainless steel fitting had been welded into a nickel-copper alloy piping system. The fitting had been certified by the manufacturer as nickel-copper, and had all the required certification data including chemistry and inspection results. In fact the words "nickel-copper" were actually etched in the fitting. Yet it was the wrong material! The system was intended for sea water service; had it been placed in operation with this stainless steel fitting a serious casualty would have resulted. In checking with other customers of this manufacturer we found that they too had received fittings of the wrong material. The manufacturer simply had no effective quality control organization. As a result we now have to check every fitting ever supplied

this manufacturer. The check is only partially completed, but 12 fittings of incorrect material have already been discovered.

I feel rather strongly about this problem. On more than one occasion I have been in a deeply submerged submarine when a failure occurred in a sea water system because a fitting was of the wrong material. But for the prompt action of the crew, the consequences would have been disastrous.

Poor workmanship shows up glaringly in new technology such as nuclear power, missiles, satellites, but it is to be found everywhere, and everywhere it raises cost and causes delay. I assure you I am not exaggerating the situation; in fact, I have understated it. For every case I have given, I could cite a dozen more. The cost in time and money because of industry's failure to meet contractual specifications is staggering. Worse, with this time and with this money we could have developed improved nuclear power plants and produced many more of them. It is difficult for me to understand why management does not face up to its failure and its responsibility in this respect. Since contracts are sought for, they must be profitable. Despite talk of "the dead hand of government," it is public money that has paid for all major technological advances made in the past two decades; and public agencies and officials have taken the lead in getting most developments started. Surely industry has as great a stake as every citizen in helping our nation move forward technologically. Industry can best do this by meeting the rising standards of new technologies when it supplies material and equipment.

I hope what I have said will not be dismissed as "unconstructive criticism" or petulant grumbling about difficulties that "ought to be

pected." Robert Hutchins has warned that "an uncriticized society will not endure." The point I want to make is that, at the levels of technology to which we must rise, the kind of problems we in the Naval Reactors Group have had with conventional components of nuclear plants ought not to be "expected." They reveal human inadequacies that must be overcome if this nation is to be competitive with its Russian challenger and with the growing power of the European Common Market.

For the first time in our history we face competition without benefit of the special advantages we enjoyed in the past: geographic isolation; enormously greater per capita wealth in land and mineral resources; the largest internal market. From now on we must excel without these advantages. Population growth and rapid exhaustion of natural resources leave us in no better position than Russia; and a united Europe will soon have as large a domestic market as we, besides possessing great resources in human competence and ingenuity. In truth, the inefficiencies we could afford in days gone by may now seriously endanger our world position.

What I have tried today is to give you an inkling of the factors that hinder progress in reactor technology and in other new engineering development projects as well. It is a commonplace of history that great undertakings often founder because of negligence in some small detail, or because of some minor, obvious and easily corrected mistake.

I submit we must progress, and so we must pay the price of progress. We must accept the inexorably rising standards of technology and we must relinquish comfortable routines and practices rendered obsolete because they no longer meet the new standards.

This is our never-ending challenge.