

Challenger: A 'typical' accident

The Challenger accident investigation (see *PHYSICS TODAY*, August 1986, page 41) probably was more visible to the public than any products liability investigation ever undertaken. From my research on how equipment fails and how personal injuries occur, I find the Challenger accident typical of what causes our machinery to fail. Several examples will illustrate what I mean.

Recently, manufacturers have used electronic remote controls on hydraulic drives to obtain greater flexibility in the control of construction equipment. Demand for drives with electronic controls has been high, and suppliers have not been able to provide all the features the builders of construction machinery desire. One manufacturer of asphalt pavers established a team to design and construct its own electronic control system. A paver having the new electronic control system was manufactured and sold. The operators found the equipment to have many of the desirable features advertised. Unfortunately, the control system occasionally failed, in such a way that the drive accelerated immediately to full speed.

The manufacturer received complaints from users about the problem, and soon there were monthly meetings on what to do about the bad feedback potentiometer, the suspected cause of the control problem. The problem eventually was solved but not before one operator was injured severely.

In reviewing the design work I saw little indication the problem ever was understood very well. The only information in the design file on the feedback potentiometer was the manufacturer's specifications for the potentiometer, given in terms of military standards. I found no evidence of any attempt to relate the military specifications to the environment in which the potentiometer was to operate. When I called the manufacturer of the potentiometer and asked what model would be satisfactory for the particular application, the response included the specific information that the model used on the paver was not suitable because of known problems with heat, humid-

ity, vibration and dirt in similar applications.

Having neglected the opportunity to learn from those similar applications, the paver designers then did not test the equipment to verify the design. The accident was, to borrow words from the Challenger commission's report, "rooted in history."

The second example involved the manufacture of a cover plate that contained a lever to operate an electrical toggle switch. A manager in a plant suggested an alternative, cheaper design for the cover plate. He constructed a prototype and set it on his windowsill to observe. After a while, he recommended that the new cover plate be manufactured. Unfortunately, the shaft assembly was weak, and after some wear the lever on the cover plate could indicate that the electrical switch was open when it actually was closed. At least one experienced electrician was electrocuted using a defective cover plate. The designer did not understand the materials he was using and did not test the assembly to verify the design. Again, the accident was rooted in history.

The interesting aspect of reliable design is that highly technical knowledge usually is not a central problem. The problem often is the inability to recognize reality in simple technical issues. The Challenger accident seems to have been similar. Richard Feynman was on target when he said, "For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled."

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10/86

Phase problems

"Direct methods" for solving the phase problem in small-molecule x-ray crystallography have received attention following the award of a Nobel Prize to Herbert A. Hauptman and Jerome Karle (*PHYSICS TODAY*, December 1985, page 20) for their pioneering contributions. Phase determination in small-

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