FAILURE EXPERIENCE AS A TOOL FOR EVALUATION OF NUCLEAR STRUCTURES

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High reliability in nuclear structures is attainable only because previous failure experience with comparable installations can be factored into structural evaluations in such a way that unsatisfactory experience is forestalled. The use of corrective techniques to eliminate in-service faults in consumer products as a means of improving the characteristics of future products is a well-known quality control principle. This principle is only applicable to nuclear structures if the nature and causes of structural failure are fully understood.

Three criteria govern the optimized relationship between failure consequences and failure characteristics. These are summarized as follows.

1. Events that might lead to poor operating load factors must be controlled in a way that minimizes damage, shortens repair time, and eliminates most significant operating delays.
2. Events that might cause significant property damage and thereby be costly to the owner must have an actuarial relationship that enables insurance premiums to remain within economic practicality.
3. Events that might infringe on the limits of public safety have to be considered in terms of frequency and time span that are in balance with other known and commonly accepted public risks.

The attention given to the third criterion has been highlighted by public safety issues, but the first two criteria are often more demanding. The actions taken to satisfy the first two criteria introduce engineering restraints that must be compatible with the third criterion. This compatibility requirement must be satisfied by concurrent treatment of the combined criteria since the governing strength of each criterion can vary greatly within a nuclear system. Consequently, failure considerations in one application have to be analyzed in a new context if they are to provide the basis for judgments concerning structural reliability in a different application.

The development of some well-established structural practices that evolved through the correlation of failure experience with structural evaluation methods is discussed in this paper. Attention is then directed to the use of analogous experience in nuclear applications as an approach to the attainment of suitable structural failure characteristics. Such factors as misjudgment of structural loads, design oversight and error, manufacturing and construction flaws, and systematic interaction are individually discussed as separate contributors to structural failures. Controlled failure is shown to be the main line of defense in attaining structural adequacy regardless of structural adversities.

A recognized shortcoming in the use of failure experience as a basis for judging structural adequacy is the paucity of statistical data to support the evaluation process. The use of calculational and experimental methods that simulate failure characteristics as a substitute for real experience is a valuable adjunct to such statistical data. The correlation between actual failure experience and simulation techniques is set forth as a crucial feature of nuclear structural evaluations with careful interpretation of actual failure causes and effects as the prime control on structural evaluation methods.

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DISCUSSION

Q R. HAUSERMANN, Switzerland

1. You mentioned that the problems in nuclear and conventional systems are similar.
2. The repair of a nuclear system, however, is much different due to the "high" radiation level.

This being the case, the design of a conventional and a nuclear system must be different particularly in that you have to use remote tooling to reduce the radiation problem.

In conclusion: I believe that it is difficult to extrapolate from conventional to nuclear systems.

A M. BENDER, U. S. A.

Obviously, it is difficult to extrapolate directly. But if one takes into account the context of the failure it is possible to include the contingencies that change the context and arrive at a rational extrapolation.

Q O. KELLERMANN, Germany

Ich begrüße Ihre Absicht, die Erfahrung konventioneller Anlagen zugrunde zu legen bei den Zuverlässigkeitsuntersuchungen nuklearer Komponenten. Aus der Erfahrung möchte ich zwei widersprüchliche Beispiele zitieren:

1. Kein Betreiber eines fossil-beheizten Kessels würde die Ausfallraten für seine Rohre akzeptieren, die bei Brennelementhüllrohren festgestellt werden.
2. Die Ausfallraten konventioneller Druckbehälter sind erheblich höher als für Reaktordruckbehälter tolerierbar. Nur bei Einführung der richtigen Randbedingungen sind Vergleiche möglich.

Haben Sie irgendwelche Erfahrungen mit Vergleichen konventioneller und nuklearer Komponenten ?

A M. BENDER, U. S. A.

Mr. Kellermann's excellent study of vessel failures is one of the basic pieces of information from which this paper was derived. Agreed that the failure experience with ordinary vessels is inapplicable to nuclear vessels, it still gives guidance in how to improve nuclear vessel reliability. Further, nuclear vessel reliability characteristics could be attained in conventional vessels if the application required it.

With respect to boiler tubes vs fuel elements faults the failure criteria are similar but boiler tube faults are undetected and therefore ignored until catastrophic faults make the boiler inoperable while in fuel elements the faults are detected and selectively evaluated. Thus in fuel elements we have rationally interpreted failure criteria.