TABLE I

System	Loss of Redundancy	Permitted Operating Time
Auxiliary power supply	Auxiliary external source	2 days
	Emergency diesel generator	14 days
	Internal sources (2 diesel generators)	18 h
Safety injection	1 HP pump	10 days
	2 HP pumps	10 h
	1 LP line	60 h
	1 HP accumulator	5 h
Containment spray	1 spray line	3,5 days
Service water	1 line	2 days

2. assessment of reliability parameters (failure rates and repair times) of the components through inquiries in EdF nuclear and conventional plants

3. use of a computer code developed especially for this case.

Results

To date, the method has been applied to several PWR systems: auxiliary power supply, containment spray, safety injection, and service water. Table I shows the allowed operating times.

OPTIMAL TEST FREQUENCY FOR THE STANDBY SYSTEMS

Method

The standby systems components can fail:

1. during their normal standby state
2. at the time of demand
3. during operation (test or accidental conditions).

The system unavailability is a function of the reliability parameters related to the various situations and to the test interval, which is the only free parameter. The optimum test interval corresponds to the minimum value of this function.

Results

To date, the method was applied to the emergency diesel generators and to the containment spray system; optimum test intervals of 360 and 650 h, respectively, were found.

In these cases, the minimum value of the unavailability function is not very sensitive to the interval value, which gives flexibility.

We consider that probabilistic methods provide a more objective tool for making such decisions, by contrast with some rules of thumb that may have been used previously. However, the results depend on the statistical data and should be considered only as a guide, which should improve when more and better data are collected.

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4. A. BLIN, A. CARNINO, and G. JUBAULT, "Programme de Calcul de la Fiabilité des Systèmes Complexes PATREC-DE, Basé sur la Reconnaissance des Formes," Congrès de PERROS-GUIRREC (1974).

5. The Concept of Exclusion Area and Its Application to Simultaneous Accidents at Multiple-Reactor Sites, *Roberto Y. Hukai, Murilo D. Santina, Chihiro Kikuchi, Daniel K. S. Ting (IEA-Brazil)*

The purpose of the present paper is to suggest several terms that might be useful in clarifying the intent of 10CFR100 for the analyses of potential accidents at sites planned for multiple reactor units.[1] The terms we propose are *twin* and *geminate*, to distinguish two types of dual-reactor construction practices, and *internally coupled* and *externally coupled* accidents, to distinguish two kinds of simultaneous accidents.

The internally coupled accidents are those that arise when an accident in one unit propagates to other units at the same site. Such accidents could be caused by fire and/or propagating malfunctions of components or systems serving several units simultaneously. An example is the recent Browns Ferry fire. Externally coupled accidents are those caused by agents external to the reactor, such as chemical explosions, extreme weather conditions, or seismic effects. Thus, for example, if all reactor units on a particular site were symmetrically built, a seismic effect strong enough to cause damage in one unit will most likely cause the same accident in others.

Twin reactors we define to be independent reactors built at the same site, such as the two German reactors planned for Angra dos Reis, Brazil. For this pair of reactors, the degree of internal coupling could be small, but we note that the probability for externally coupled

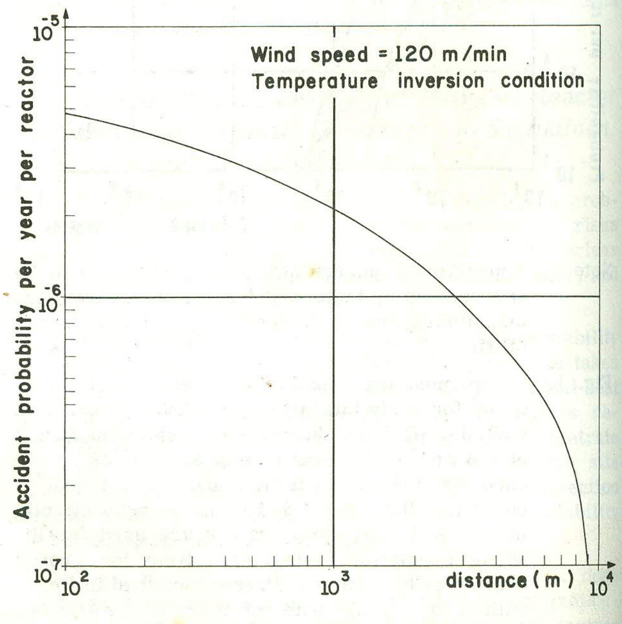

Fig. 1. Accident probability per reactor per year as a function of the radius of the exclusion area.

accidents from seismic effects could be reduced further by misalignment. *Geminate* reactors we define to be those reactors sharing certain facilities, such as those being built in the United States. The degree of internal and external coupling is potentially larger than for twin reactor systems.

We have used the ACRA-II Code to calculate the exclusion radius for the nine categories of accidents examined in WASH-1400, as applied to the Angra I PWR site.[2-4] The calculations are based on whole-body dose of 25 rem in 2 h, and meteorological conditions of 2 m/s wind speed, inversion, flat terrain, and Pasquill E (see Fig. 1), the predominant weather condition there. Note that the exclusion radius of 800 m, used for Angra I, corresponds to a probability of 2.4×10^{-6} per reactor per year, or to one maximum credible accident in about 400,000 reactor years.

If, however, the possibility of simultaneous multiple reactor accidents needs to be taken into account, the exclusion areas would need to be enlarged considerably; for example, by a factor of 2 for the three Angra reactors [1 of 624 MW(e) and 2 of 1300 MW(e)]. It should be stressed, however, that for Angra dos Reis the degree of internal and external coupling is extremely small.

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3. G. W. PARKER and G. E. CREEK, "The Volatilization of Fission Products by Melting of Reactor Fuel Plates," ORNL-CF-57-6-87 (July 1957).

4. K. H. LINDACKERS and W. STOEBEL, "Probability Analysis Applied to LWR: Loss-of-Coolant Accidents," *Nucl. Safety*, 14, 14 (Jan.-Feb. 1973).

6. Reactor Scram Experience for Shutdown System Reliability Analyses, *G. E. Edison, S. L. Pugliese, R. F. Sacramo (WARD)*

The importance of the reactor shutdown system (RSS) to safety in nuclear power plants is well known. The control rods and instrumentation are relied on as the primary means of shutting down the nuclear reaction. For this reason it is essential to provide a reliable RSS.[1]

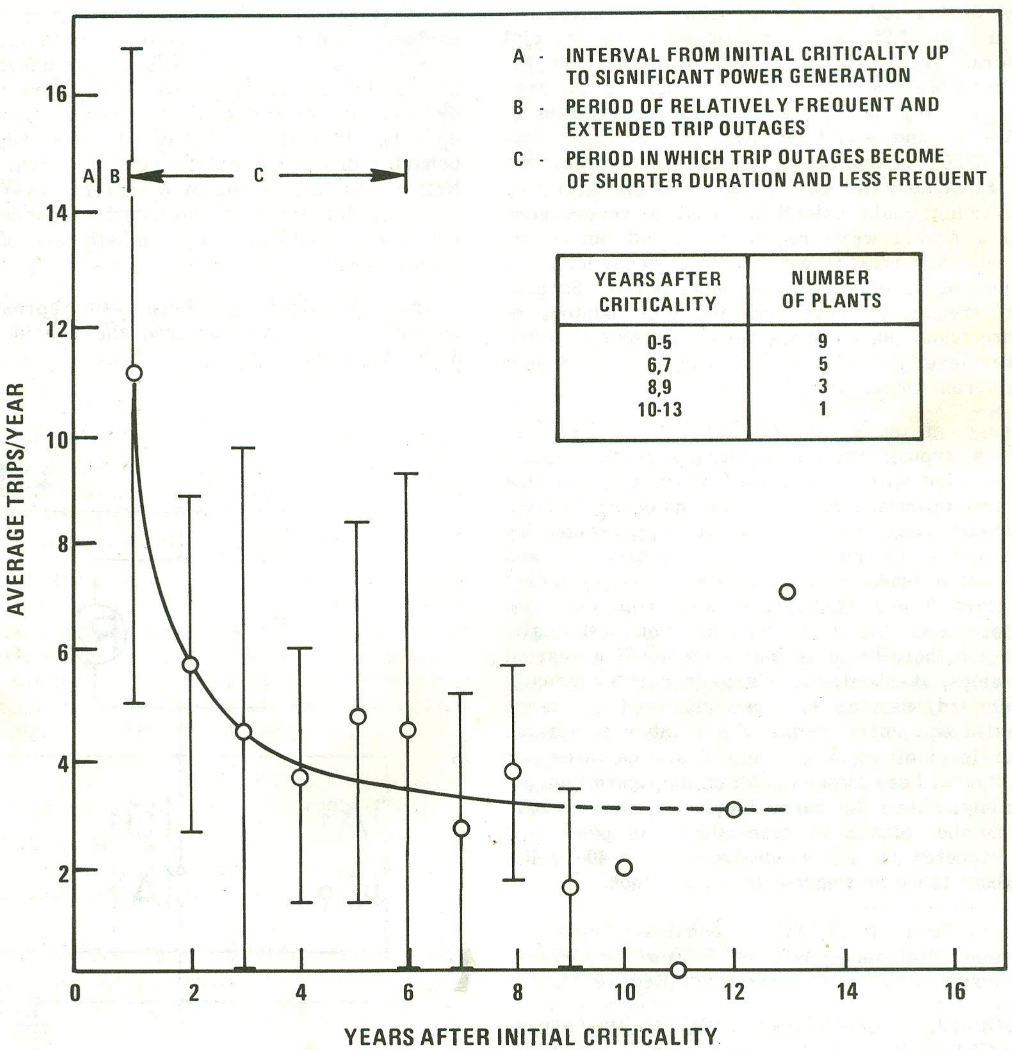

Fig. 1. Annual rate of reactor trips from above 20% of full power averaged over selected light-water reactors.