

# The Risk of a Nuclear Reactor Disaster

Utility companies, to support their claims of nuclear reactor safety, present artificial risk estimates — such as no more than one core meltdown per 30,000 years of reactor operation — that are based on faulty assumptions, guessing, and unvalidated theoretical models. Our only solid source of information on reactor risk is the historical record. According to the International Atomic Energy Commission (2013), as of 2012 a total of 581 civilian reactors had logged 15,247 years in operation. There have also been three major reactor accidents: Fukushima, Chernobyl, and Three-Mile Island (counting the three reactor accidents at Fukushima as a single event). This produces a rate of 3/15247 or 0.000197 such accidents per reactor-year. That number may seem small, but, as we shall see, it actually indicates extreme danger.

The number calculated above is an empirical rate based on a limited sample. What we really seek is the long-run population risk rate. (Similarly, we might flip a coin twice and observe heads both times, making the empirical proportion 1.0, but the long-run population rate is 0.50.)

Because the numerator of our fraction, 3/15247, is a count, one can use the Poisson distribution to compute a *confidence interval* to identify the range of likely population risk rates around the historical risk rate. Such intervals vary in width according to how conservative we wish to be. A non-conservative approach would simply accept 0.000197 as the population rate. A minimally conservative estimate would be the value for which the chances of underestimating true risk are only 20%. Moderately and strongly conservative estimates make the chances of underestimation of true risk 10% and 5%, respectively.

Using a well known method (Garwood 1936; Soper 2015), we obtain variously conservative estimates of the population risk of a major reactor accident per reactor-year as shown in Table 1 (Column 2).

**Table 1**  
**Risk of Reactor Meltdown Disaster for a Single Site and Total Risk in US Over 25 Years**

Level of Conserv- ativeness	Risk (Reactor/Yr)	Total Risk (25 Yrs, 1 Site)	Total Risk (25 Yrs, All Sites)	Total Risk (40 Yrs, All Sites)
<b>Nonconservative</b>	0.000197	0.49%	38.9%	54.5%
<b>Minimal</b>	0.000362	0.90%	59.5%	76.5%
<b>Moderate</b>	0.000438	1.09%	66.6%	82.7%
<b>Strong</b>	0.000509	1.26%	72.0%	92.8%

*Example.* For an observed count of 3, the 90th percentile estimate of the expected long-range average count is 6.68. Dividing this by 15247 gives 0.000438, the moderately conservative estimate of risk of a major meltdown per reactor-year.

While the risks per reactor-year may look small, the problem is that we have to consider the Total Risk in operating a reactor over time, and, on a national scale, many reactors over time. Total Risk is the probability of at least one major event happening in a certain length of time. For a single reactor, this is given by the formula:

$$\text{Total Risk (\%)} = 100 \times (1 - (1 - \text{Risk})^{\text{Years}})$$

where Years is the window of time. So, for example, the Total Risk of at least one major meltdown accident at a given reactor (say, Diablo Canyon) over 25 years ranges from a

minimum, nonconservative estimate of 0.49% (about one chance in 200), to more appropriately conservative estimates of about 1% to 1.25% (or one chance in 100 or 80, respectively). These values are alarmingly high. (Ask yourself: would you eat a jellybean from a jar of 100 knowing that one contains cyanide?)

The danger becomes even more apparent when we consider Total Risk nationwide. Here the formula becomes:

$$\text{Total Risk (\%)} = 100 \times (1 - (1 - \text{Risk})^{\text{Reactors} \times \text{Years}})$$

Assuming that 100 reactors operate in the United States for an average of 25 years each, the conservatively estimated Total Risk of at least one meltdown accident ranges from about 60% to 72%. (Over 40 years, even the nonconservative estimate is above 50%.) These estimates are consistent with other recent analyses (e.g., Ghys 2011; Smythe 2011; Lelieveld et al. 2012; Ha-Duong & Journé 2014).

One can easily imagine a utility company looking at these results and countering: "You can't go by past events. The industry learns from mistakes. Reactors today are better designed and safer than those at Chernobyl and Three-Mile Island." However it is unlikely that today's American reactors are better designed than those at Fukushima. Further, more complex designs supply new opportunities for malfunction. And human error is always a danger.

In short, if we base risk estimates on the historical record — our best, most objective, and perhaps only reliable source of data — it is more likely than not that a serious accident will occur at one or more US reactors within the next 25 years. The unacceptability of this risk becomes even more salient when we consider that we are all neighbors. An accident that happens anywhere in the country is not "the other guy's problem." We're all in this together.

## References

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