Three Mile Island

The TMI-2 Accident Consequences and Costs

Jack DeVine

NEA Workshop, Paris, May 2013

Today's Discussion

- A quick refresher on the TMI accident
- Consequences and their costs
  - The obvious direct consequences, and the less obvious – indirect ones
  - Partial quantification
- Some perspectives on TMI consequences and costs

March 28, 1979 – In Brief

- A relatively minor secondary plant equipment failure caused the automatic plant shutdown
- During the subsequent post trip transient, an automatically operated relief valve stuck open, allowing coolant to leak from the reactor
- This small break loss of coolant (SBLOCA) was not detected by plant operators and continued unabated for over two hours.

March 28, 1979 (continued)

- In their confusion, the operators compounded the problem by reducing, then stopping, automatic safety injection.
- Results:
  - Extensive fuel damage, including partial (~ 1/3) core melt
  - Hydrogen release and deflagration, in containment
  - Extensive release of fission product activity, primarily in-plant (most in-containment), and off-site release of noble gases

Years of Recovery

- Months to fully stabilize the plant
- Two years to determine the actual extend of damage
- Six years to restart the undamaged TMI-1
- 12 years and ~$1billion (direct) to clean up the mess
- 33 years later: no new nuclear plants built in the U.S.

TMI Impacts, Broadly

- The Good
  - **No-one hurt**, on site or off
  - Environment unharmed
  - The rugged containment really worked
- The Bad
  - Brand new, multi-billion dollar plant destroyed
  - A fine company nearly bankrupted
- The Really Bad
  - We terrified our neighbors and many others
  - We derailed a booming, important industry
  - We were lucky – it could have been worse

Direct Consequences / Costs

- Those stemming directly from the accident and ensuing plant damage and release of radioactive material:
  - In-plant emergency response (weeks)
  - Plant stabilization, accessibility and characterization (years)
  - Fuel removal, packaging, storage and disposal (years)
  - Waste Processing, storage and disposal (years)
  - Deactivation, long term monitoring and ultimate decommissioning (decades)

Indirect Consequences / Costs

- Immediate:
  - Public sector emergency response
  - Economic consequences to displaced citizenry, commerce and business
  - Replacement power cost (from loss of TMI-2 AND TMI-1)
- Sustained economic consequences
  - Loss of asset (TMI-2) by GPU, plus permanent cost of replacement power
  - Extended TMI-1 outage (six years)
  - Depressed economy / housing valued in TMI area

Indirect Costs (continued)

- Nuclear Regulation and Oversight
  - Extensive examination, research and development of revised standards and practices
- Nuclear Industry impacts (US and international)
  - New nuclear plant cancellations, terminations or non-orders – with cascading impacts on suppliers, engineers, constructors, infrastructure, etc.
  - For nuclear plant licensees / operators
    - Compliance with new regulations, including backfits
    - New training requirements and costs
    - New emergency management facilities and operations

Indirect Costs (continued)

- US Energy Supply
  - Diminished reliance on – and availability of – nuclear energy, continuing today
- The environment
  - Environmental consequences and costs associated with higher dependence on fossil fuels, continuing today
- International Consequences
  - In general, parallel and similar, but less severe than in the US

TMI Costs – in Perspective

- At TMI, the damage was well contained and direct costs limited accordingly
  - Primary on-site damage to the reactor, nuclear fuel and reactor containment
  - Essentially no off-site damage, radiological or otherwise
  - No impacts on infrastructure or accessibility
  - In those respects, the TMI accident was fundamentally different – and less consequential – than Chernobyl and Fukushima.

Perspectives (continued)

- Not all of TMI's consequences were negative:
  - Changes to nuclear plant design, operations, training, regulation and oversight resulted in substantial, sustained improvements across the US commercial reactor fleet:
    - Increases in reliability and capacity factor
    - Better radiological controls and reduced exposures
    - Higher readiness for nuclear incidents or accidents, with actual application in other industry/public events
    - Likely (but unquantifiable) avoidance of other nuclear events
  - As a result, Nuclear energy everywhere is more economical and safer

Perspective (continued)

- Indirect costs were amplified by the fact that TMI was the first large scale commercial accident
  - Industry and public were unprepared
  - Public trauma and loss of confidence have had continuing, severe consequences
  - Absent TMI, these 'first accident' impacts would have affected someone else, later.

Quantifying the Cost Impacts

- Some cost components are known or are estimable:
  - Direct private sector costs
  - Public sector near term costs

Quantifying the Costs (continued)

- Indirect costs are subject to high uncertainty, because of:
  - Costs and consequences ('what –if' costs) of alternative scenarios are essentially unknowable
  - There are other factors that were likely to interrupt the nuclear boom
  - Raging debate over macroscopic issues such as environmental pros and cons of reduced dependence on nuclear.
  - Off-setting costs are difficult to gauge

TMI Costs (my guess)

- Direct costs: $10 -20B (USD), including:
  - GPU Loss of capital asset and cleanup program costs
  - Government costs in accident response, cleanup support
  - Current owner plant maintenance and ultimate decommissioning
- US Nuclear industry costs: $10 – 60B, including:
  - Fleet wide plat backfits and regulatory requirements

TMI Costs (the imponderables)

- **Net** cost of other intangibles is very uncertain:
  - A crippled nuclear industry - **but** other energy sectors pulled up the slack, and existing US plants delivered far more power than ever anticipated due to reliability improvements, power stretching, life extension).
  - Long term effective constraint in expansion of nuclear generation – **but**, there was certain to be some expansion fall off due to demand shifts, alternative fuel costs, etc.
  - Replacement power costs are estimable – **but** the hard part is guessing how many nuclear plants were never built.
  - Environmental consequences and costs? To be debated forever.
- Actual costs are in the nature of **lost opportunity**

The Bottom Line

- TMI accident direct consequences and costs were relatively low, compared to other severe industrial accidents, nuclear and other:
  - Chernobyl and Fukushima
  - BP Horizon Oil Spill and Exxon Valdez
  - Bhopal
- TMI indirect consequences were enormous – and they are in evidence even today, 34 years later