Quantifying Total Losses Due to Fire-Remembering the Browns Ferry Nuclear Plant Fire

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This year marks the 30th anniversary of the landmark fire at the Browns Ferry Nuclear Power Station. On March 22, 1975, employees inspecting penetration seals for air leakage accidentally started a fire, which damaged over 1,600 cables, including 628 that were "important to safety" 1 at the facility. The event has had far-reaching impact on the fire protection community – particularly in regard to cables and penetration seals, or more correctly, firestops.

Many lessons can be learned from this fire, but one stands out above others. The lesson of how a fairly small fire can cause tremendous financial disruption and damage is exemplified in this case as in few others. Certainly, other largeloss fires have been reported, and they too had far-reaching economic impacts in addition to their role in shaping fire protection. However, nuclear facilities are usually remote from populated areas, and often they are the major employer in an area, resulting in potentially greater local or regional economic impact in the event of a fire. What is the total monetary impact of a fire at one of these facilities? As with most large fires, a large value, which is often difficult to quantify. For example, for industrial fires, there is the actual fire loss – the facilities, equipment, or inventory directly impacted by the fire. Then there are the business interruption costs. This can move far beyond the actual loss to sales or other income, and in some cases may also include the costs of purchasing goods or services from competitors in order to meet obligations. The least visible of all is often the impact on the local economy.

THE INCIDENT 2

On the day of the event, at approximately 12:15 pm, workers at the Tennessee Valley Authority facility near Athens, Alabama, were working to resolve an air leak in a fire penetration seal. As is normal in nuclear facilities, ventilation is designed to flow from areas of lower contamination levels to areas with potentially higher levels.

A cable penetration between the cable spreading room and the reactor building had been identified as a leak point, and plans had been developed for repair. The penetrations were two "stacks" of five trays each which passed through a square four-foot by four-foot (1.2 m x 1.2 m) opening. The trays themselves did not pass through the two-foot (0.6 m) thick reinforced concrete fire wall. The seal, designed as both an air seal and a firestop, consisted of formed-in-place polyurethane with a fire retardant or protective material applied to the exposed polyurethane face. A candle was used to locate the specific leak point by observing flame movement caused by the airflow. Once the specific location was identified, polyurethane foam sheet material was inserted as necessary and the candle used to determine effectiveness of the repair. This time, however, the flame was pulled into the opening by the airflow. The polyurethane material, not yet protected by the fire-retardant material, ignited.

Attempts by the workers to extinguish the fire were complicated by the depth of the seal, the fact that the seal did not extend to both faces of the wall (the seal was installed at the

reactor building side), impediments caused by the penetrating items, and by the lack of immediately available and appropriate means of extinguishment. Once obtained, a CO2 extinguisher was perhaps compromised by the airflow, rendering it ineffective.

The fire ignited the polyvinyl chloride (and other) insulated cables. It was later estimated that about 4,000 pounds (1,800 kg) of cable insulation was involved, releasing an estimated 1,400 pounds (600 kg) of chloride to the reactor building. Damaged components included electrical power, plant control systems, and instrumentation cables. 1

Reference	Loss Reported	Summary
Industrial Fire Protection Handbook 4	$500 Million	Total loss, no breakdown of category
NFPA *Fire Protection Handbook* 5	$227 Million	Described as property damage
Energy Power Research Institute (EPRI) [6]	$1 Million	Characterized as "direct" loss and identified a "forced outage of 550 days"
SFPE Technical Report 77-22	$380 Million-450 Million	Includes property damage of $10 M, cost of replacement electrical power of $300,000 – $500,000 per day for 18 months (total $200 M-$270 M, loss of investment return of $170 M.
Fire Journal, July 1976 3	Over $130 Million	Property damage of $10 M, replacement power costs of $10 M per month for over a year

HOW MUCH? WHEN?... AND HOW?
Bad news travels fast, and reporting of a fire when it is "fresh" doesn't always offer the benefit of offering the total cost of the fire. The Browns Ferry Fire is a good example. The July 1976 Fire Journal reported that the "property damage... is estimated at about $10 million, and the cost of replacement power was approximately $10 million per month." 3

Another factor is determining the period of time during which the loss estimates-were established. In other words, is the estimate in current valuations, or is it the actual value when the event occurred? For example, if one uses a $100 million damage assessment under the assumption that the referenced value was in 1975 dollars, then, according to a conversion using the Consumer Price Index (CPI), the value in 2003 dollars would be $342 million.

Also of concern is the method for making the conversion. There are at least five methods for converting past values into current dollar estimates. All five will give different results, and choosing the most accurate is a point of debate, since there is no common

agreement on which is the most accurate. The most commonly used is the Consumer Price Index. It is familiar to most people and is useful for comparing the cost of average household items. The Gross Domestic Product (GDP) Deflator is similar to the CPI, but includes all items produced in the economy. A third method, the GDP, is the market value of all goods and services produced in a year. The fourth is the GDP per capita, and the fifth is the Unskilled Wage Rate.

APPLES AND APPLES

Some estimates of the consequences of the fire refer only to the actual physical damage at the facility. In reality, this was very small for the Browns Ferry fire. It has been reported that only 20 feet (6 meters) of cables were directly involved in the fire. However, the consequences of this "small fire" resulted in what was determined to be a property damage estimate of up to $227 million – the cost of replacing all of the damaged cables – not just the damaged sections. Other sources report estimated damage at $500 million. 4

Of larger importance are the costs of repairs and the loss of production capability. The fire in 1975 impacted both units at the site (a third was under construction). Each unit was capable of producing 1,065 MW of power, and both were out of service for eighteen months.

A review of the literature reveals a wide discrepancy in the total reported or estimated loss due to the fire at Browns Ferry. (See Table 1.) There are several reasons for this. First among these may be the fact that the facility was self-insured, and either a comprehensive assessment of the total impact of the fire was not performed or, if performed, was proprietary.

An obvious factor is scope of the estimate. Some references identify only firerelated property damage, while others include property damage and business interruption costs. None of the references reviewed captured the additional cost of repairs. SFPE Technical Report 77-2 offered a possible estimate of over 1,000 person-hours for repairs (including overtime). 2 Other costs for interaction with the Nuclear Regulatory Commission or testimony before the Congressional Joint Commission on Atomic Energy as well as recovery planning would also have added to the total cost.

The SFPE report also calculated a loss of return on investment of $170 million based on a 10 percent return on the $1 billion facility.

Direct loss is the term used to describe the damage to the building, its contents, and occupants (deaths or injuries), while costs associated with a fire following extinguishment are indirect or consequential losses. 7 Consequential losses include loss of production, profit loss potential, loss of employment, and costs of recovery, including repair and replacement. These losses can be particularly significant when specialized equipment or components are damaged and require long lead times for replacement.

LOCAL IMPACTS

One area of economic impact which is harder to quantify than others is that of the local economy. A major fire can significantly influence the economy of the local community – positively or negatively. In the case of a fire where the company decides to rebuild, the construction activities may bring jobs. Either new construction jobs become available or

workers come from other areas. In the latter case, local lodging and food service establishments may benefit. Conversely, normally assigned workers may be laid off during the construction. If the plant decides not to rebuild, the local economy loses jobs. What is often not realized is the hidden impact of this job loss. For example, local businesses which rely on sales or services to the former employees will likely see a decline in revenue.

A fire protection engineer bears quite a responsibility when one considers that the potential consequences of a bad decision or poor judgment can reach far beyond the boundaries of the affected facility. Fire protection engineers also have to be salespeople – it is often their job to convince a client or manager of the need for fire protection systems or features. Recognizing the business interruption and other consequences of a fire is critical in making fire protection decisions. Fire protection engineers are necessary in evaluating risks and also providingbalanced fire protection at a level appropriate to minimize the risk to acceptable levels. The SFPE report2 indicates that this is one lesson learned from the incident – two fire protection engineers were added to the staff following the Browns Ferry event.

Ultimately, the total costs of the Browns Ferry fire will never be precisely known. Costs resulting from this fire include its effect on the commercial nuclear industry. New regulations, additional oversight, changes in procedures, new fire analyses, additional or more frequent inspections, and many more related activities came about following the fire. While incalculable, these costs have been estimated to be in the billions of dollars.

Of course, all of the economic impacts pale in comparison to the primary role of ensuring life safety and the consequences of failure on that front. Reflecting on the Browns Ferry fire can serve as an effective reminder of how important the fire protection engineering profession is – and how necessary.

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