

Protection money

Ten years ago BC Hydro decided to insure itself against fire risk and started a program to make realistic cost allocations.

Fire protection engineering is interdisciplinary in nature. An effective team requires electrical engineers for the increasingly complex alarm, detection and protection systems, mechanical engineers to design sprinkler systems, fire fighting gases and hydraulic systems, structural engineers for fire stopping, fire doors and fire separation, and construction materials specialists. As buildings and construction materials change and alarm and detection instrumentation become more sophisticated, the need for expertise in fire protection systems will continue to grow.

The expansion in fire protection engineering is being driven from several directions. Life safety concerns continue to take a prominent role in planning as evidenced by the growth in environmental engineering. Yet municipalities are under pressure to reduce fire fighting resources, and fire insurance premiums and deductibles are becoming excessive.

As resources shrink, life safety has to be improved by other means. In 1991, Vancouver became the first municipality in North America to mandate sprinklers in all new residential construction, and in 1997 followed with industrial and commercial buildings. Sprinklers and other fire protection measures are proving effective in saving lives, reducing property losses, and reducing insurance premiums.

Ten years ago BC Hydro management decided to stop buying fire protection insurance when the annual premiums were expected to rise from \$500,000 to \$2,000,000, with a low (\$15,000,000) ceiling on claims and a

high (\$5,000,000) deductible. As most policies insure for the rare low frequency events with high losses, instead of insuring for the more common high frequency events with low losses, it no longer made business sense to continue paying large premiums as well as pay for the damage after a typical event, which rarely cost as much as the deductible. With the start of the Fire Risk Reduction Program (FRRP) in 1986, the company approved the concept of self-insuring itself against fire risk to the sum of half the insurance premiums, or \$1,000,000 a year.

BC Hydro's analysis is based on comparing the total expected loss to the probability of a fire (see case study). Al Bolger, P.Eng. is the engineer of record for fire protection for BC Hydro's Transmission and Distribution and Power Supply groups. He elaborates on the development of a risk analysis method that has proven to be an effective tool for allocating fire risk funding. He says that most of the critical fire protection measures for the Transmission and Distribution group are complete. Of the 32 power generating stations, however, only three have been upgraded to date.

"Since upgrades that are needed to improve life safety are recommended and installed without further analysis, we focus on finding the best way to determine which remaining systems will be retrofitted based on a benefit/cost ratio" explains Bolger. Any measure that is

above an acceptance level of 2 is installed, while those that have a ratio below a rejection level of 1 are not. Systems that fall between acceptance and rejection are subjected to an analysis which examines the societal consequences of system failures. A sensitivity analysis adjusting variables such as the value of the plant, the frequency of the design fire, or the cost to borrow money for retrofits or fire damage repairs is carried out to see if the benefit/cost ratio is over sensitive to any one variable.

New fire protection codes are easy to incorporate into new construction. With large older facilities, however, it may not be possible to take measures such as installing more stairwells or sealing off existing ones. "Since we cannot always meet the current code, we try to determine which fire protection measures we can install that will save lives based on the probability of a fire starting in a given location, and the probability of fire and smoke spreading. It is not an exact science, but it is our best judgment. And we haven't been far off the mark when you compare what our computer models are predicting with data that is published by EPRI (Electric Power Research Institute), IEEE (Institute of Electrical and Electronic Engineers) and other professional societies in terms of fire frequencies and vulnerable equipment," explains Bolger.

Studies to evaluate how fire and smoke move throughout a plant and what time is required

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to vacate buildings are carried out, then a computer model is used to find the exit time from the most remote location. "Areas where we cannot retrofit to meet the fire code are evaluated and 'code equivalencies' are introduced that are signed off by the engineer of record."

This method of allocating fire protection funding can be applied to any building or industry. BC Hydro is currently working with Ontario Power Generation to assist in setting up a similar program. The methods that BC Hydro is pioneering, and the money that has been saved on insurance premiums since 1986, clearly demonstrate that building managers don't have to, and in fact shouldn't, rely completely on fire insurance brokers to identify deficiencies, dictate (possibly expensive) remedial measures and impose unrealistic timelines.

In the long term, BC Hydro is interested in working with consultants to offer complete fire protection engineering services by building a diverse and versatile pool of expertise in fire protection engineering systems and risk analysis.

CASE STUDY

A typical hydro-electric generating station fire risk analysis

This example of a fire risk analysis uses a typical hydro-electric generating station with a generation capacity of 607.5 MW. The major components are the powerhouse, control building, office building and the dam. Using an event tree, each component was broken down until every room, vestibule, corridor, spillway and washroom was examined. Two probabilities were assigned to each component, the probability of a fire occurring, and the probability of that fire spreading. The consequences of each event were quantified by identifying output in MW hours/week, maximum outages in weeks, annual loss risk in MW hours, equipment replacement costs, and annual equipment loss risk.

Using an event tree, each component was broken down until every room, vestibule, corridor, spillway and washroom was examined.

During the detailed inspection stage, the analysts identified remedial measures and compiled installation costs. Remedial measures fall into four categories: life safety items (which are installed in BC Hydro facilities without further analysis), passive measures which include fire separation and fire stopping, active measures which involve installation of detection and fire fighting systems, and manual measures such as fire hoses and fire extinguishers.

Several life safety, passive and active measures were identified for the control building. Some of the life safety items identified (and subsequently installed without further analysis) are as follows: installing manual pull stations at the exit stairs, installing a two hour rated fire separation around the stairs, installing self illuminated exit signs at all exit points from each floor and from the building, upgrading the emergency lighting to provide the required illumination at locations where the present lighting was insufficient, and ensuring duct detectors in the fresh air intake system can shut down the HVAC system in the event of a fire.

The passive measure identified for the control building was to install two-hour rated fire stopping at all locations where major cable penetrations of floors and walls had not been firestopped.

The active measures identified for the control building were to allocate a pro-rated cost for the computer based detection system, to install a pre-action sprinkler system with on-off heads activated by air sampling detection throughout the control and switchgear rooms, and to install a wet pipe sprinkler system throughout all areas in the

control building not covered by the pre-action system.

The following example examines installing the pre-action sprinkler system with on-off heads activated by air sampling detection throughout the control and switchgear rooms:

The probability of any fire in any power station is a 1 in 10 year event, $P_f = 0.1$. The first branch of the event tree breaks this power generating station down into four areas, the powerhouse, the control building, office building and the dam. The probability of a fire in the powerhouse is estimated to be $P_{f_{\text{power house(ph)}}} = 0.70$, control building $P_{f_{\text{control building(cb)}}} = 0.15$, office building $P_{f_{\text{office building(ob)}}} = 0.10$, and in the dam $P_{f_{\text{dam(d)}}} = 0.05$.

Within the control building itself, the probability of a fire on the main, second, third and fourth floor are; $P_{f_{\text{cb(main)}}} = 0.10$, $P_{f_{\text{cb(second)}}} = 0.10$, $P_{f_{\text{cb(third)}}} = 0.50$, and $P_{f_{\text{cb(fourth)}}} = 0.30$ respectively. The probability of a fire in the control room on the second floor is $P_{f_{\text{control room(cr)}}} = 0.95$. The probability of that fire spreading from the control room is $P_{f_{\text{cr(spread)}}} = 0.005$. To find the estimated probability of a fire in the control room, $P_{f_{\text{cr}}} = P_f \times P_{f_{\text{cb}}} \times P_{f_{\text{cb(second)}}} \times P_{f_{\text{cr}}} = (0.1) \times (0.15) \times (0.1) \times (0.95) = (0.0014)$. The probability that a fire would spread from the control room is assigned a conditional probability of, $P_{f_{\text{cr}}} = P_f \times P_{f_{\text{cb}}} \times P_{f_{\text{cb(second)}}} \times P_{f_{\text{cr}}} \times P_{f_{\text{cr(spread)}}} = (0.1) \times (0.15) \times (0.1) \times (0.95) \times (0.005) = 7.1 \times 10^{-6}$.

If this fire is contained within the control room, the maximum outage caused would be one week. If the fire spreads and destroys the control building, the maximum outage would be up to 104 weeks. If the fire spreads from any area, the assumption is that the whole control building will be destroyed.

The annual revenue loss risk for the control room is \$45,000. This is determined by multiplying the probability by the average generation output of the plant. The average output is based on historical operating records. The

annual revenue loss risk for the generating station if the fire were to spread and destroy the building is \$27,500, a smaller number because the probability is low. The annual equipment loss for the control room is \$30,000. The cost of secondary equipment rentals that would be required to continue supplying electricity is not included in this example.

The calculation of the benefit/cost ratio of installing the system uses net present value figures that take financing and maintenance costs into account, amortized over 25 years. The net present value cost to install the pre-action sprinkler system with air sampling detection is \$137,000. The net annual benefit (ignoring societal benefits) is \$1,104,000.

In this simple example the system had a benefit/cost ratio of 8.1 (\$1,104,000/\$137,000) and was therefore installed. Sometimes in evaluating options other variables will enter into the equation. If a sprinkler once installed, for example, could accidentally (or intentionally) be activated, the cost of the water damage to sensitive electrical and computer equipment also has to be plugged into the benefit cost analysis. **CCE**

Tonia Jurbin, P.Eng. is a writer in Burnaby, B.C. and works for BC Hydro.

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