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# A Model for Assessing the Cost/Benefit of Risk Reduction Alternatives

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## Introduction

In today's business environment, managing risk is an important cost control center of any management function or situation. Understanding the true cost of risk and safety is a task that is subjective at times, objective at others. Often, a hazard evaluation will identify hidden costs and potentially huge future losses for a business or organization that are not known or fully evaluated in the present.

Applying a systematic Hazard Evaluation and Control approach to analyzing risk, and assigning dollar cost values to identified hazards and their control strategies, is an excellent method to maximize your organization's risk management dollar and identify previously unknown or poorly evaluated hazards.

The importance of using a systematic approach cannot be overemphasized. Such an approach will allow dissimilar hazards, their associated risks, and dissimilar Hazard Control Plans, to be analyzed in an apples-to-apples cost comparison. Such a Cost/Benefit Analysis applied to Organizational Risk and Hazard Control shows quantitatively which risks are the largest for the organization and how much they are costing the organization annualized year after year. In addition, the same methodology can be used to evaluate the Cost/Benefit of any proposed Hazard Control measures, and identify the largest Return on Investment (ROI) for any Hazard Control Strategy.

Systematically applying Hazard Identification, Evaluation, and Control is a continuous process that is part of any highly functional organization's management discipline. This process is outlined in a flow chart at the end of this article. Once the Controls are put in place, the evaluation process should be repeated to make sure the controls are mitigating risk as planned and within budgeted cost.

## Hazard Identification, Evaluation and Control

To do a systematic Cost/Benefit Analysis of Hazards and their Controls, the hazards must be identified, evaluated, and a series of controls must be considered. Once the controls are known, they can be evaluated to determine if they function to control the hazard to an "Acceptable Level of Risk".

## The Organization's Level of Risk Tolerance

How does your organization define an 'Acceptable Risk'? Depending upon the nature of your organization, the type of business, the potential for harm, and the resulting losses from hazards, your organization will have a unique level of risk tolerance that must be addressed in any Hazard Control process. There are several methods that can be used to evaluate hazards and risk tolerance level of your organization, but the easiest to comprehend and apply is the Risk Matrix. Each hazard has a frequency and severity rating associated with the hazard. Plotting frequency versus severity on a matrix allows comparison of dissimilar hazards and the specific levels of risk associated with each one. For example, a hazard that may result in a major loss such as a building fire (high severity), but is highly unlikely to happen (low frequency), may be of lower risk to the organization than a hazard that may result in minor injury (relatively low severity), but is likely to happen to multiple people in the course of a week's time (very frequently). By understanding the associated frequency and severity ratings for each hazard, all hazards can be plotted on a matrix for comparison, where one axis are the gradations of frequency and the other axis are gradations of severity. Each evaluated hazard will fall at some point on the matrix based on its Frequency and Severity rating. Hazards that are of higher risk (i.e., higher frequency and severity ratings) can be slated for Hazard Control Plans. Hazards with lower risk are likely left alone with no action to control them needed. Each Organization must determine what will be its Hazard Control action threshold to determine the hazards that will be worked on.

The risk matrix can be used not only to determine a level of risk tolerance for an organization, but also to evaluate the impact of various Hazard Control Plans. In addition, it may become the key cost driver when determining the impact various Hazard Control Plans will have on the organization's bottom line.

## Hazards to be Controlled

Responsible people within the Organization must first identify hazards that are determined to be a threat to the organization's well being in some way. These may be in the form of employee injury potential, facilities loss, business interruption, public impression, injury to general public, injury to the environment, etc. This brainstorming process creates a Hazard List of all hazards associated with the part of the Organization being analyzed. Once the Hazard List is determined, then each hazard can be evaluated for Frequency and Severity to determine which hazards have the most potential for loss to the Organization and are candidates to be controlled.

## A Hierarchy of Hazard Control Options used to control the hazard(s)

Once it is known which hazards are candidates for control, each hazard needs to be analyzed for Control Options. It is important that all control options be included in the Control Option List as the hazard may be controlled by one option, or a combination of Control Options may be needed to adequately control the hazard. In all cases, it's important to look at the Hazard Controls with an eye toward creating a hierarchy of control options. First, eliminate the hazard all together through process, equipment, or other means of Organizational change. Second, control the hazard to an acceptable degree through engineering means. Third, administer the hazard controls through safety programs and procedures. And, finally, isolate the hazard to remove or lower its potential for loss.

Often it may appear to be the most expensive alternative to eliminate the hazard altogether even though from a safety engineering perspective this may be the preferred methodology of Hazard Control. Conducting a Cost/Benefit analysis can often demonstrate a greater payback to the Organization through Hazard elimination, than to have to manage and pay for a Safety / Hazard Control Program well into the future.

### Controlling Hazard(s) at an Acceptable Level of Risk

Now that there is a list of Hazard Control Options, and the Organization's level of risk tolerance is known, the Control Options can be evaluated to determine if they will meet the requirements of the Organization's level of risk tolerance individually. If a single Hazard Control Option does not control risk to an acceptable level, the analyst may consider a combination of more than one Control Option to create a situation that controls the hazard to an Acceptable Level of Risk for the Organization.

### Creation of Several Hazard Control Plans

From the list of Hazard Control Options, create a minimum of three workable "Hazard Control Plans" that will control the hazards to an Acceptable Level of Risk. For example, in a current situation a large metal working machine has hazards associated with mechanical parts, manually feeding materials into the machine, high heat, and stored energy. A Hazard Control Plan may require that machine guards and an interlocked control system be engineered and installed on specific functional areas of the machine. In addition, a Lock out / Tag out energy isolation program as well as a Hearing Protection Program may be needed. And, during routine work, operators may need to wear high temperature protective clothing, protective eyewear, footwear and gloves. In addition, operators may need to be rotated in / out of the job every two hours due to the physical strain manually handling product. So a Hazard Control Plan would include all of these hazard controls that function together to lower the risk of operating the machine to an Acceptable Level.

A second Hazard Control Plan may look at the same metal working machine, and determine that the existing manual material feeding process could be replaced by a newer process that would completely isolate the machine operator from the hazard through automating the material feed systems, installing sound absorption materials and heat shields. This Control Plan would require additional capital investment and engineering, but the need for a Hearing Protection Program, operator rotation, and Personal Protective Equipment (PPE) worn by machine operators would be eliminated. In addition, this work process would be more user friendly, have a likely 20% increase in productivity, and 20% reduction in quality rejects.

A third Hazard Control Plan might look at replacing the existing machine and process line all together. The new machine and process line would be fully automated and the machine operator would be located in an air-conditioned control room in another part of the facility. The new machine would increase productivity by 100% and would reduce quality rejects to less than 0.1%. The Hazard Control Plan would require a Lock out / Tag out Program, and some machine guarding, most likely light curtains that will shut down the operation immediately when the curtain wall is violated. The job of the current machine operators would be eliminated and there would be no need for PPE or a Hearing Conservation Program, or to rotate operators.

## Cost/Benefit Determination

Now that there are three hazard control plans, the Cost/Benefit Model may be applied to determine the Plan that makes the most "business sense" to implement. The following steps define the process of the Cost / Benefit Model:

## Determine the "Project Lifetime" in years

All Hazard Control Plans must have an end point. This is a point in time where it is known the hazard(s) will diminish or disappear. This could be when a process is planned to be discontinued, when capital equipment is fully depreciated and anticipated to be obsolete, or when new equipment or a process will replace existing one(s). In any case, the analyst must choose a "Project Lifetime" in years to determine the total "Project Lifetime Cost" of each Hazard Control Plan.

For example, in the event new capital equipment is purchased to control hazards, the "Project Lifetime" for the equipment would be the estimated length of time the equipment would be functional over its intended life. This could be longer than the depreciated time, but for the sake of cost comparison, use the total time the equipment will be depreciated as the "Project Lifetime". In looking at a current situation, assume the "Project Lifetime" would be the remaining number of years the process or equipment is expected to function without major capital investment or process improvements.

## What are Recurring, One-time and Potential Costs?

There are three different types of costs associated with any Hazard Control Plan. These are Recurring Costs, One-time Costs, and Potential Costs. So what are these costs and how are they determined?

A "Recurring Cost" is a cost that occurs again and again and is associated with a process or Hazard Control Plan. For example, a machine operator's salary would be a 'Recurring Cost'. Other Recurring Costs would be the cost of electricity used to power the machine, or a preventive maintenance program to keep the machine functioning safely and properly, or the cost of running a Hearing Protection Program because the ambient noise around the machine is above the Permissible Exposure Level.

A "One-time Cost" is a cost that is incurred once, and when the money has been spent, there is no further cost to implement that part of the Hazard Control Plan. For example, if equipment is needed to be purchased and installed to implement a Hazard Control Plan, the costs of procuring, designing, installing, and debugging the equipment would all be One-time costs. Once the equipment is installed and functioning properly, there would be no more costs associated with the equipment installation.

A "Potential Cost" is a cost that may occur due to a hazard that leads to a loss, or a malfunction of the process or equipment. For example, a pressure vessel may have a pressure relief valve on it to assure the vessel will never get over-pressured. If the valve were to malfunction and the vessel were to get over-pressured and explode, the costs associated with the process shut-down, equipment repairs / replacement, the loss of production, and medical costs of any injuries associated with the incident would all be "Potential Costs". Inclusion of "Potential Costs" in any

Hazard Control Plan cost calculation is very important because they account for hidden costs that all Organizations assume for unforeseen incidents that could occur.

## The need to Annualize Costs

When preparing to complete a Cost/Benefit analysis of any Hazard Control Plan, it is important to understand the three costs associated with each plan, but two of them also need to be annualized. By annualizing costs, it allows the analyst to compare dissimilar Hazard Control Plans with various strategies, life-time horizons of the Control Plans, and resulting costing structures in an apples-to-apples comparison over a set period of time (one year).

"Recurring Costs" are naturally annualized. All Recurring Costs are generally calculated over a year's time, or if they are calculated over a different time period, they are easily annualized by dividing the Recurring Cost by the number of years associated with the cost. For example, a Respirator Program has cost $100,000 to implement and manage over the past 4 years. The "Recurring Cost" of the Respirator Program is $100,000 / 4 = $25,000 per year. In another example, disposable gloves used to protect worker's hands in a new process that has been running for 3 months (0.25 years), have cost $500. The annualized Recurring Cost of disposable gloves would be $500 / 0.25 = $2000 per year.

"Potential Costs" are based upon both the frequency and the severity of hazards. So, for example, if the previously described boiler were to explode, the injuries, process interruption, and facilities degradation would likely be very costly, say in the range of $30,000,000. But, the likelihood of this happening is very low, for example estimated at once every 300 years as long as the preventive maintenance is kept up on the pressure relief valve. A determination of the annualized "Potential Cost" associated with the boiler exploding, would be $30,000,000 / 300 years = $100,000 per year. Besides being an annualized "Potential Cost" associated with the boiler, this calculation demonstrates the cost savings every year associated with the preventive maintenance on the boiler's pressure relief valve.

"One-time Costs" do not need to be annualized to complete a Cost/Benefit calculation as will become evident shortly.

## Determine the annualized "Recurring" and "Potential" costs to maintain the Status Quo

Now that the concepts of annualized costs are understood, it's time to determine the costs associated with maintaining the Status Quo. The Status Quo also has a Hazard Control Plan associated with it, and this needs to be evaluated to create a 'base line' cost of doing business. This cost needs to be known to determine if there are savings and a "Return on Investment" associated with any changes from the Status Quo. Because the Status Quo is an existing situation, there are no "One-time Costs" associated with maintaining the 'Status Quo'. Calculate the Recurring and Potential Costs associated with maintaining the Status Quo and add them together to determine the total annualized cost for maintaining the Status Quo.

## Determine the annualized "Recurring" and "Potential" costs of each "Hazard Control Plan"

To determine the total annualized cost for a Hazard Control Plan, add the Recurring and Potential Costs together. Do this calculation for each Hazard Control Plan being considered.

## Determine the One-time Cost for each "Hazard Control Plan"

Each Hazard Control Plan will likely involve One-time Costs. Calculate the One-time Cost associated with each Hazard Control Plan by adding the various costs of purchased components, engineering, construction, etc. into the total One-time Cost for the Plan.

## Summation of these annualized costs and Multiplication by the "Lifetime" in years

To obtain an apples-to-apples comparison of cost, the longest "Lifetime" in years of each of the Hazard Control Plans will be the number of years it is assumed that all Hazard Control Plans will function.

Once the longest "Lifetime" is known, multiply this value by the sum of the annualized Recurring and Potential Costs for each of the Hazard Control Plans. Then, add this cost and the One-time Cost associated with the Hazard Control Plan to obtain the total Hazard Control Plan Cost over its Lifetime.

For example, if a Hazard Control Plan to band-aid a piece of production equipment has a Project Lifetime of 4 years, and another Hazard Control Plan to replace the equipment all together has a Project Lifetime of 12 years, then for the sake of comparison the analyst will use a Project Lifetime of 12 years as the multiplier of all annualized costs in each Hazard Control Plan. Each Plan's annualized Recurring and Potential Costs would be multiplied by 12 and the One-time Cost would be added to these costs to obtain the total Hazard Control Plan Lifetime Cost for that Plan.

## Simple Math Cost / Benefit ratio and Payback Period

Once the Lifetime Cost for maintaining the Status Quo and the Lifetime Cost for each Hazard Control Plan is known, then several simple calculations may be completed to determine the Payback Period in years otherwise known as the Cost/Benefit ratio. To determine the Cost / Benefit ratio, conduct the following calculations. First, determine the Lifetime Cost Savings of each Hazard Control Plan as follows:

- The Status Quo Lifetime Cost minus the Hazard Control Plan Lifetime Cost = the Lifetime Cost Savings of the Hazard Control Plan.

If there is no Lifetime Cost Savings associated with the Hazard Control Plan, the Status Quo should likely be maintained as there is no cost justification for further action. If it's determined that action still must be taken, then the least costly Hazard Control Plan would make the best business sense.

If there are Lifetime Cost Savings associated with the Hazard Control Plan, determine the Annual Savings of the Plan as follows:

- Lifetime Cost Savings of the Hazard Control Plan divided by the Control Plan's Lifetime in Years = Annual Savings of the Hazard Control Plan.

Then, to determine the Cost/Benefit ratio:

- The Hazard Control Plan One-time Cost divided by the Annual Savings of the Hazard Control Plan = Cost/Benefit ratio = Payback Period in Years.

A Cost/Benefit ratio of 1 equates to a 1 year payback. A Cost / Benefit ratio of 2 equates to a 2 year payback, etc. The shorter the Payback Period, the more financially attractive the Hazard Control Plan.

Other Accounting Measures that can be helpful

With some additional calculations using depreciation schedules, projected financing costs, current corporate bond discount rates, etc., a determination of Net Present Value of each Hazard Control Plan can be determined. Net Present Value is a more accurate accounting method that takes into account the future cost of borrowing moneys to fund an Organization's activities. It is far more involved and in the realm of corporate accounting and financing. Using Net Present Value may be important when analyzing costs in a large capital project that will be funded through corporate borrowing, or may be applied on a smaller scale dependent upon the Organization's need.

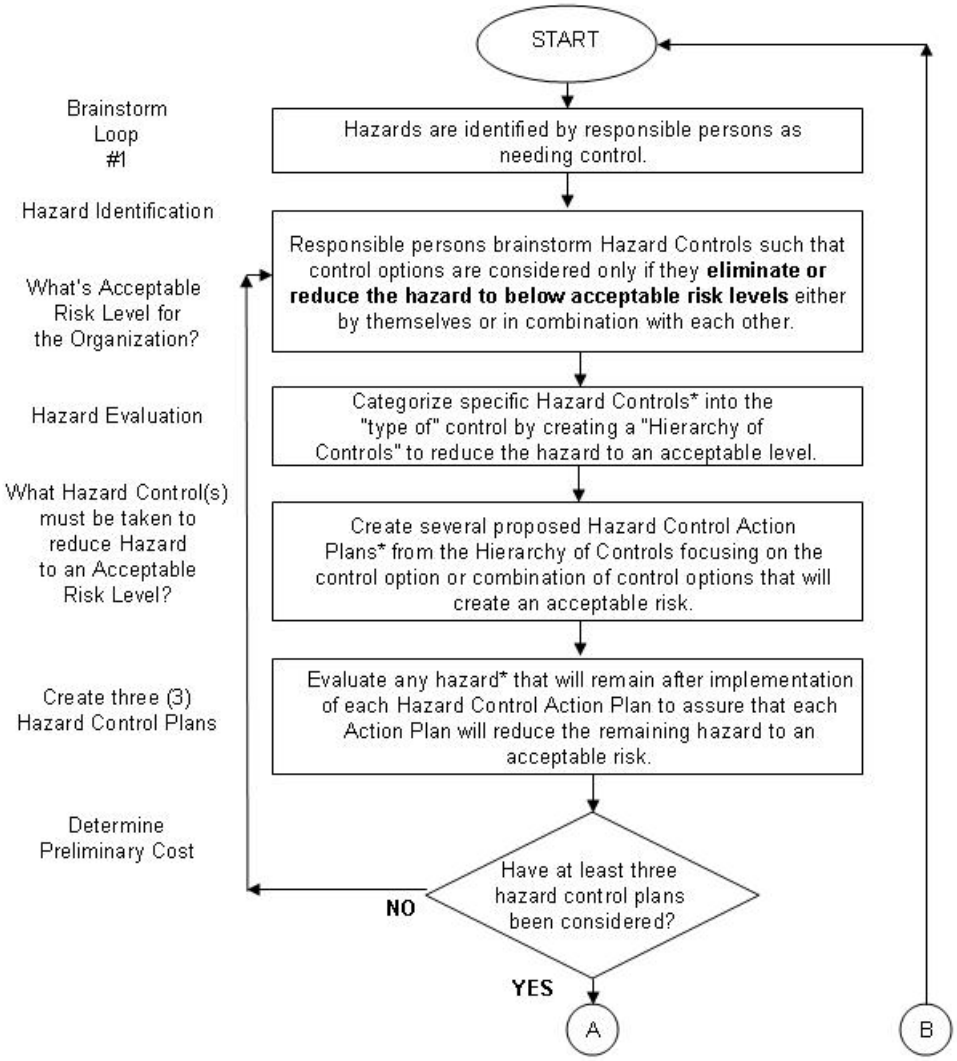
Comparison of Cost/Benefit ratios for different Hazard Control Plans

Once the Cost / Benefit ratios for each Hazard Control Plan are known, they can be compared to the cost of maintaining the Status Quo in a single summary sheet delivered to Organization Management. Management can then determine the most financially appropriate course of action to take to control the Hazards to an Acceptable Level of Risk.

## Summary

Using a Safety Engineering Cost-Accounting Model such as the one described in this paper will allow the safety professional to put into business language what needs to be known by accounting, finance and business managers in order to make a reasoned business decision when looking at various Hazard Control alternatives. Such a tool has been developed into a software program and applied to business decision making processes with great success. It can be custom tailored to a business's level of risk tolerance and provides an apples-to-apples comparison of dissimilar Hazard Control approaches, while taking into account the cost of potential future losses if various control systems fail. It is a tool that can be systematically applied to any management system, equipment purchase, process, or product modification, and has the potential for a far reaching and highly profitable impact on the cost of doing business.

# Hazard Control Process Flow Chart




* These are subjective processes and rely on the expertise of personnel conducting the analysis.

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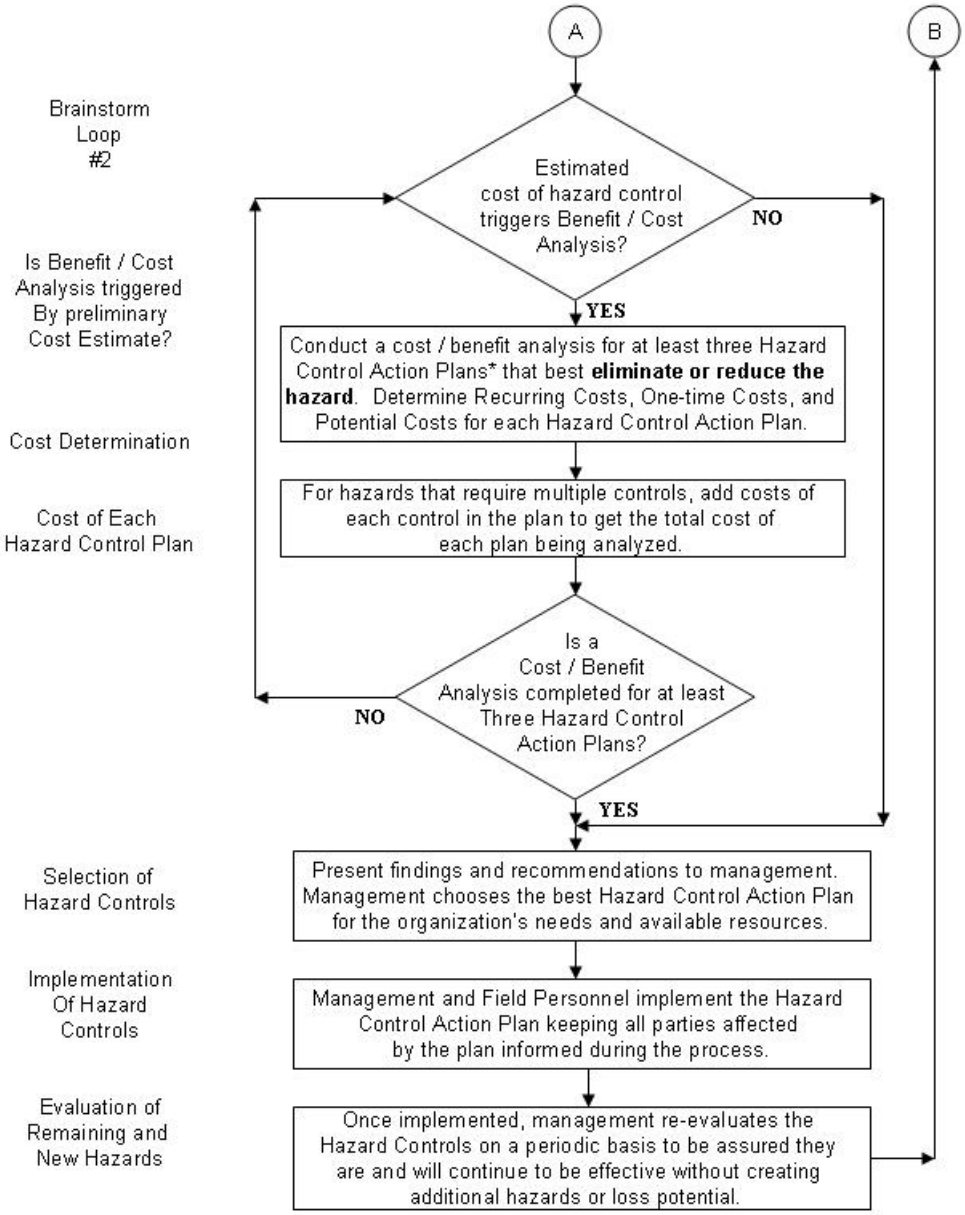


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