THERP, and cost-effectiveness Each has a number of variations and more than one may be combined in a single analysis

Failure mode and effect. In the failure mode and effect method, failure or malfunction of each component is considered including the mode of failure (such as, switch jammed "on"), the effects of the failure are traced through the system, and the ultimate effect on the task performance is evaluated Failure mode and effect analysis is straightforward assuming that the analyst is thoroughly informed about the system One drawback of this method, however, is that it considers only one failure at a time and thus some possibilities may be overlooked

Fault tree In the fault tree method an undesired event is selected and all the possible happenings that can contribute to the event are diagrammed in the form of a tree The branches of the tree are continued until independent events are reached Probabilities are determined for the independent events and after simplifying the tree, both the probability of the undesired event and the most likely chain of events leading up to it can be computed

This is a very powerful analysis technique but has the drawback of requiring a fairly heavy mathematical background and a good computer to obtain the maximum benefits of the method Boeing Company has refined the fault tree method to a high degree and has found it practical for analyzing aerospace products

THERP THERP, technique for human error prediction, developed by Sandia Corporation, provides a means for quantitatively evaluating the contribution of human error to the degradation of product quality It can be used for human components in systems and thus can be combined either with the failure mode and effect or the fault tree methods

Cost effectiveness In the cost effectiveness method, the cost of system changes made to increase safety are compared with either the decreased costs of fewer serious failures, or with the increased effectiveness of the system to perform its task, to determine the relative value of these changes Ultimately all system changes have to be costed, but this method makes such cost comparisons explicit Moreover, cost-effectiveness is frequently used to help make decisions concerning the choice of one of several systems which can perform the same task

In all of these analytical methods the main point is to measure quantitatively the effects of various failures within a system In each case probability theory is an important element

Deviation caused by change

In any process or system, there is some risk When something *changes,* accompanied by an *error,* there is an *accident* The error can be either active or latent For example, in a highway crash, a dog might run across a highway (the change), the first driver slams on his brakes, but there was too little space between him and the car behind (a latent error) The deviation is a two-car accident The accident, a deviation, interrupted the task performance

When a safety change is planned, unwanted changes must be anticipated (*a*) An offsetting safety change can be made to channel unwanted change aside or get rid of it (*b*) Or the change can be kept from affecting the error situation (*c*) Or the error can be kept from resulting in an accident (*d*) If there is an accident, its adverse results can be minimized by providing personal protective equipment (*e*) If there is an injury, then it can be treated In some cases, a new and better way can be found to do the task, thus avoiding the trouble-spot entirely

The objective of a plan for safety changes must be to help task performance The objective of accident investigation (discussed in Chapter 12) is to determine the facts that produced the "change," and to take countermeasures to offset this change so that the desired task may be completed

Value of systems approach

The industrial safety engineer might well ask what all this "systems analysis" have to do with him The answer to that question, and the major point of this discussion, is that anyone can use and profit from the systems approach to safety The systems notion helps to enlarge one's viewpoint Becoming oriented in terms of task performance and being forced to visualize the interrelation-