Chapter – 4

Safety, Responsibilities and Rights

4.0 SAFETY DEFINITION

Safety has different connotations. A product or a project is safe, with respect to a person or a group, at a given time, if its risks were fully known, and if the risks are judged to be acceptable, in the light of settled perspectives. When based on judgment safety, can be taken as objective. If the perspectives on values are taken then safety can be subjective as well.

Awareness and maintenance of this situation is called 'safety'. The safety can be incorporated during design, pre-testing, operation, field applications, analog tests, and learning from the past or others.

The perception varies from person to person, based on one's physical condition, age, experience, expertise, and wisdom. A second-hand electric heater when purchased was alright. But when used it might give electric shock and damage the human. Chlorinated municipal water supplied may be considered as unsafe we may judge that the harm to the stomach is unacceptable. But it may really safeguard against *gastroenteritis*. Sometime, the individual or groups think motorbikes are unsafe and scooters are safe. Some may never think about safety at all. An aged person is likely to suffer from dust. A scissor with the child may be unsafe, but with an adult it can be safe.

Various factors that influence the perception of risk are:

1. Probability of risk (the statistical nature of occurrence of risk).
2. Consequence of the risk. This is a quantitative measure. It can be physical damage or death of people, economic loss or damage of property, loss of money or reputation, degradation of the environment, and sometimes mental agony.
3. Voluntaryness (i.e., for thrill and amusement or under compulsion (involuntaryness).
4. Magnitude i.e., number of people or extent of area involved.
5. Proximity, the closeness of relationship with those affected or the gap in time scale.
6. Method of information dissemination on risk.
7. Job-related, i.e., whether it is under compulsion or volition.

The knowledge of risk acceptance is useful to the engineers. The designer can redesign the product/project to include safety measures, so as to (*a*) allow the product fail safely, (*b*) abandon it safely, and (*c*) provide for safe escape/evacuation from the product or site, and thus eliminate or minimize the human loss.

4.1 SAFETY AND RISK

Safety was defined as *the risk that is known and judged as acceptable*. But, risk is a potential that something unwanted and harmful may occur. It is the result of an unsafe situation, sometimes unanticipated, during its use.

Probability of safety = 1 – Probability of risk

Risk = Probability of occurrence × Consequence in magnitude

Different methods are available to determine the risk (testing for safety)

1. Testing on the functions of the safety-system components.
2. *Destructive testing*: In this approach, testing is done till the component fails. It is too expensive, but very realistic and useful.
3. *Prototype testing*: In this approach, the testing is done on a proportional scale model with all vital components fixed in the system. Dimensional analysis could be used to project the results at the actual conditions.
4. *Simulation testing*: With the help of computer, the simulations are done. The safe boundary may be obtained. The effects of some controlled input variables on the outcomes can be predicted in a better way.

4.2 RISK ANALYSIS

4.2.1 Analytical Methods

Several analytical methods are adopted in testing for safety of a product/project.

1. Scenario Analysis

This is the most common method of analysis. Starting from an event, different consequences are studied. This is more a qualitative method.

For example, a disaster recovery plan, for an organization is discussed. When the probability and size of loss (indicating possibility and financial significance, respectively) are both high, risk exists. On the other hand, risk is not associated with very low probability of occurrence, or with losses that under any other circumstances would be considered “affordable”. But there is a gray area between probability/loss combinations that are truly risky, and those that are not. This reflects the fact that the boundary between risky and non-risky events is fuzzy, not exact.

To assess the risk faced by the organization, the planner matches the probability and loss characteristics of various exposures to one’s intuition of risk. This exposure analysis can be most effectively carried out using ‘loss scenarios’. A scenario is a synopsis of events or conditions leading to an accident and subsequent loss. Scenarios may be specified informally, in the form of narrative, or formally using diagrams and flow charts.

Steps for Risk Assessment

1. What can go wrong that could lead to an outcome of hazard exposure? (identification and characterization of risk)
2. How likely is this to happen? (quantification of risk, likelihood, and magnitude)

3. If it happens, what are the consequences? Scenarios are constructed and the ways and means of facing the consequences are designed.

Consider three loss scenarios facing the company which is transporting various cargoes, some hazardous. The three scenarios involve the legal liability arising from use of company vehicles on public roads. The probability/loss combinations associated with these scenarios are 0.1, 1, and 10.4% Scenario A represents an upset or overturn of a truck carrying dangerous cargoes in a populated area. It is further assumed that the spill leads to an explosion or release of toxic chemicals. Scenario B represents the company's liability for an accident involving bodily injury and property damage from relatively "ordinary" road hazards. No spill or disruption of cargoes is involved. Finally, Scenario C identifies a situation involving multiple simultaneous catastrophes to the company fleet.

Scenario A has a probability of occurrence of 0.001 and a loss potential of Rs. 50 million. It is deemed sufficiently "possible" and significant so as to be unequivocally classified as "risky". Scenario B, on the other hand, while more probable than A, involves losses that this firm considers "affordable". As such, it is rated not risky with confidence. Not so easy to classify is Scenario C. While the probability of multiple catastrophes is not strictly zero, it is rare (10^{-6}, or one chance in a million). So, while the loss potential is great, the chance of occurrence is "virtually impossible". Scenario C, nonetheless, resides in that gray area of risk that results in considerable anxiety over its classification.

The steps for Scenario building may alternatively be detailed as follows:

1. Identify the hazard of interest
2. State the question to be investigated
3. Develop a planned scenario
4. Develop a scenario tree
5. Collect evidence to evaluate the nodes of the scenario tree
6. Quantify the number of scenario tree, and
7. Link the information generated by scenario analysis with empirical evidence.

Using the Scenario

The uses of scenario-based risk analysis are many and varied. The explicit analysis of scenarios may suggest ways of reducing or eliminating exposures through risk or loss-control activities. Risk or loss control actions have the effect of reducing probability and amount of risk or loss or both. Often, scenarios are posited on the basis that risk potential is as low as reasonably achievable (ALARA). This type of analysis recognizes that even under the best of risk control programs, accidents will happen.

As the cornerstone of planning, scenario-based risk analysis allows identification and prioritization of disaster potential. Knowing what can happen, and the risk involved, allows the analyst to make effective plans for safety in the event of disaster. By concentrating on risky scenarios, the disaster planner can tailor actions to exposures. This ensures the best allocation of resources at the time of crisis.

2. Failure Mode and Effect Analysis

In this method, various parts or components of the system and their modes (patterns, propagation and nature) of failure are studied. The causes of failure or the interrelationships between the components

are not studied. FMEA is one of the qualitative tools, which support proactive quality strategies. Successful implementation of FMEA requires relevant knowledge and insight as well as engineering judgment. FMEA concept was introduced in 1960s by aerospace companies. Then the use of FMEA was extended to automobile industries and other types of industries, understanding the value of this approach. In the last decade, it has undergone metamorphosis where focus was on severity, occurrence and detection rating. Thus, FMEA is defined as a systematic tool to

(*a*) identify possible failure modes in the products/process,

(*b*) to understand failure mechanism (process that leads to failure),

(*c*) risk analysis, and

(*d*) plan for action on elimination or reduction of failure modes.

A. STEPS TO CONDUCT FMEA

FMEA is a cross-functional team management. Throughout the product development cycles, changes and updates will be introduced to the product and process. These changes have to be reviewed because they can introduce new risks or failure modes. It is thus necessary to review and update changes.

1. Product/process and its function must be understood first. This is the most fundamental concept to be adopted in this methodology. This understanding helps the engineer to identify product/process function that fall with the intended and unintended users.
2. Block diagram of product/process is created and developed. The diagram shows the major components or process steps as blocks, identifies their relations namely, input, function and output of the design. The diagram shows logical relationship of components and establishes a structure for FMEA. The block diagram should always be included in the FMEA form.
3. Header on FMEA form is completed. FMEA form includes part/process name, model date, revision date, and responsibility.
4. The items/functions are listed logically in the FMEA form, based on the block diagram.
5. Then failure modes are identified. A failure mode is defined wherein a component, subsystem, system, and process could potentially fail to meet the design intent.
6. A failure mode in one component can cause failure in another. Each failure should be listed in echnical terms. Listing should be done component- or process-wise.
7. Then the effects of each risk/failure mode are described. This is done as perceived by both internal and external customers. The examples of risk/failure effect may include injury to the user, environment, equipment, and degraded performance. Then a numerical ranking is assigned to each risk or failure. It depends upon the severity of the effect. Commonly, in the scale, No.1 is used to represent no effect and 10 to indicate very severe failure, affecting system of operation and user. By this, the failures can be prioritized and real critical risks can be addressed first.
8. Then the causes of each failure mode have to be identified. A cause is defined as a design weakness that results in a failure. The potential causes for each failure mode are identified. The potential causes, for example, may be improper torque or contamination or excessive loading or external vibration.

9. The probability factor indicating the frequency of occurrence is considered. A numerical weightage can be assigned to each cause depending upon the probability of occurrence. A standard scale is used, 1 indicating 'not likely'and 10 indicating 'inevitable'.
10. Design or Process mechanism has to be identified, which can prevent the cause of failure or detect failure, before it reaches customer. Accordingly, the team has to identify tests, analysis, monitoring and other techniques to detect the risk or failure. Previously undetected or unidentified failures may appear when a new product/process are introduced. Therefore, FMEA should be updated and the required plans for the elimination of risks or failures have to be drawn.
11. Assessment of detection rating is done by assigning a numerical weightage. Value 1 indicates design control will certainly detect the potential cause, 10 indicates design control will not detect the cause or mechanism. A normal scale of 1 – 10 is used.
12. Risk Priority Number (RPN) is calculated and reviewed.

    RPN = Severity × Probability × Detection

    It is used to prioritise failure modes and viewed as a relative measure of the design risk
13. Recommended actions are determined to address potential risks or failures with high RPN.
14. Revalidate each action by reassessing severity, probability and detection and review the revised RPN. Check any further action is needed. FMEA has to be updated as and when the design or process is modified or changed.

B. STAGES OF FMEA

The analysis can be executed in four stages as given below.

Stage 1: Identifying possibilities and defining the scope. It includes function, possible failure mode, causes and effects of failure mode and detection/prevention of failure mode.

Stage 2: Measuring the volume of risk involved from the failure modes identified. It includes the probability of cause and occurrence, severity of effect and effectiveness of control to prevent cause, assessment of RPN.

Stage 3: Classification of severity of effects and the solution for the causes of high risk. Based on RPN, it prioritizes work, indicates detailed action, and assigning responsibility and target completion time to the team.

Stage 4: Revalidation of the above procedure, after corrective and preventive actions are implemented. Check whether target data and work is met. Review RPN and decide if any further action is needed.

C. FMEA DOCUMENT

The top portion of document is called *header* and mainly used for tracking. Except the first column of work sheet, all other details remain the same. The header includes following:

1. *Model no.*: It includes name and identification number of system, sub-system or component in order to avoid confusion between similar components.
2. *Prepared by*: The details like name, telephone number, address of the personnel should be included in the space for clarification, if any.

3. *Responsibility*: The team incharge of design or process should be included. It also includes the company or department of the person or group responsible for preparing the document. It is a common work sheet that can be used both for design FMEA and process FMEA.

   In design FMEA, following points are to be entered: name and number of item, listing the functions of the item (system or sub-system or component-wise), Environment in which system operates. In process FMEA, descriptions of processes, listing of processes and complete purpose of processes have to be entered.
4. *FMEA team*: The names of responsible individuals and departments that have authority to perform task are included.
5. *FMEA date*: The date of original FMEA compiled should be entered. In revision column latest revision date is entered.

Table 4.1 Worksheet for Design/Process FMEA

Model no.: *FMEA team members*					*Prepared by:* *Original FMEA date:*					*Responsibility:* *Date of revision:*					
Design/ Product	Potential cause failure	Potential effects of failure	Seerity	Class	Poten-tial cause/ Mecha-nism of failure	Occu-rrence	Current process control	Detection	RPN	Reccom mended actions	Respon sibility & target date	Action results			
												SEVERITY	OCCURENCE	DETECTION	RPN

3. Fault-tree Analysis

This is a qualitative method and was originated by Bell Telephones. It is technology-based deductive logic. The failure (undesirable event) is initially defined, and the events (causal relationships) leading to that failure are identified at different components level. This method can combine hardware failures and human failures

Example 1: Consider the failure of the steam flow in a thermal station. The water is pumped from a big reservoir nearby. The details are shown in Fig. 4.1

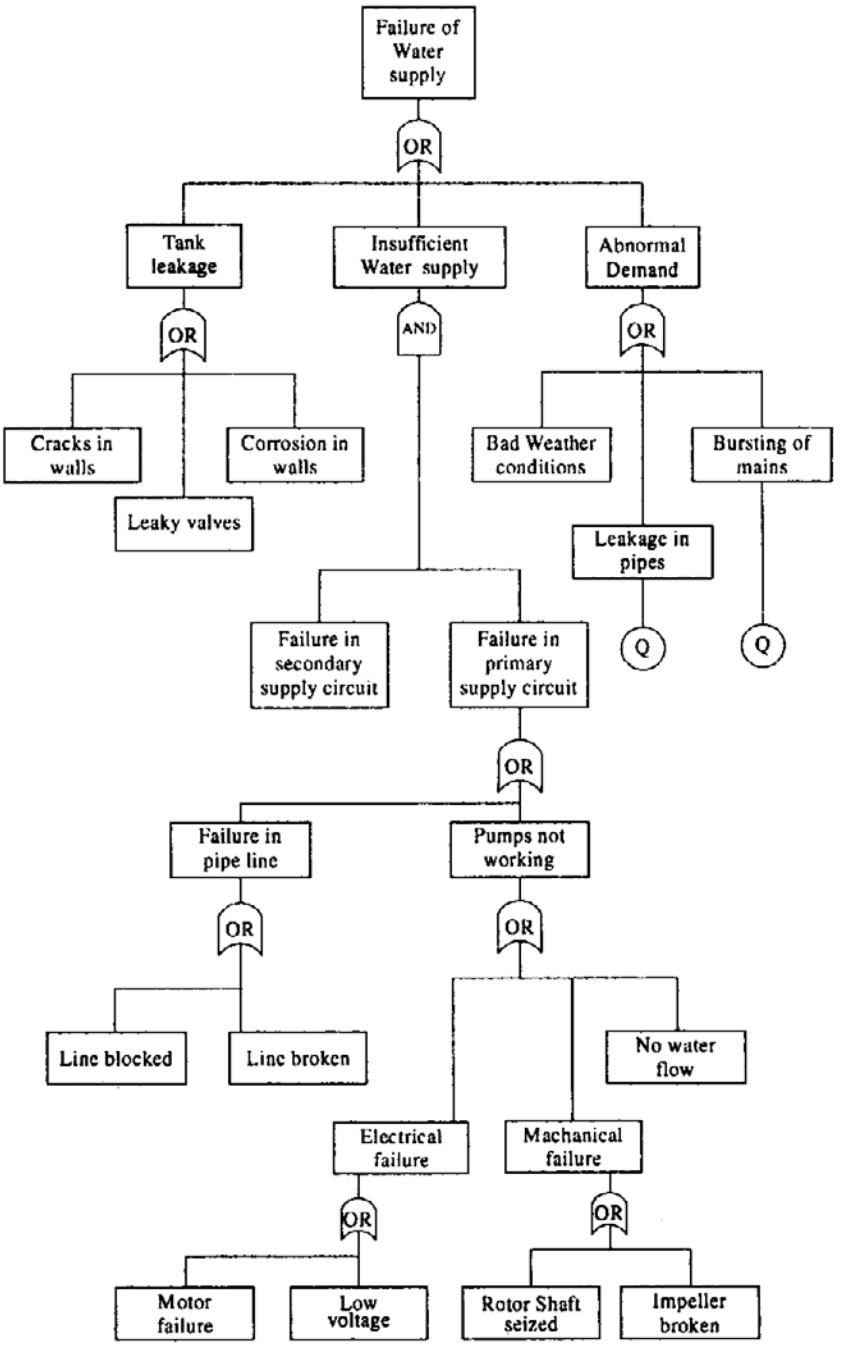

Fig. 4.1 Fault-tree analysis

The common mode event in this case is an earthquake. This quake has affected many systems or components at the same time. Hence, we can call the 'earthquake' as the common mode/cause.

Example 2: A crash at main road junction

The details of this Fault-tree Analysis are shown in Fig. 4.2

Consider the probability of the crash at a road junction and construct a tree with and AND or GATE logic. The tree is constructed by deducing in turn the pre-conditions for the final event and then successively for the next levels of events, until the basic causes are identified.

By ascribing probabilities to each event, the probability of a top event can be calculated. This requires knowledge of probable failure rates. At an OR gate, the probabilities must be added to give the probability of the next event, whereas at an AND gate, the probabilities are multiplied. This is a powerful technique for identifying the failures that have the greatest influence on bringing about the end event.

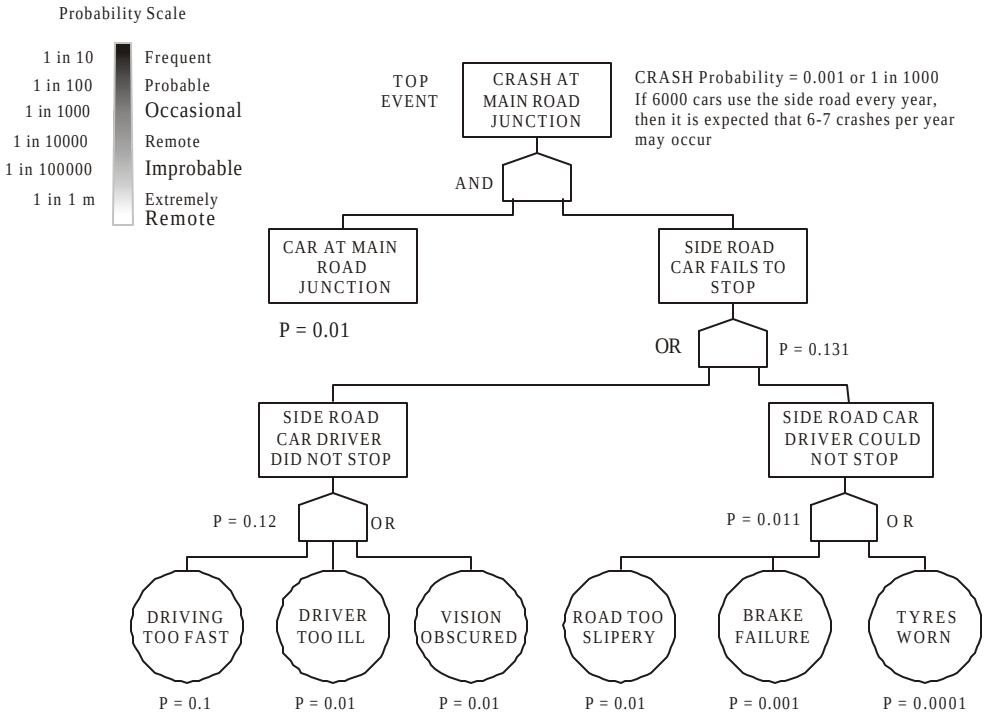

Fig. 4.2 Quantification for fault-tree analysis

Example 3: An automobile car does not start. The details of this case are shown in Fig. 4.3.

The advantages of FTA are (*a*) the primary cause can be located easily, and (*b*) It is useful in emergent situations i.e., a fire-fighting approach.

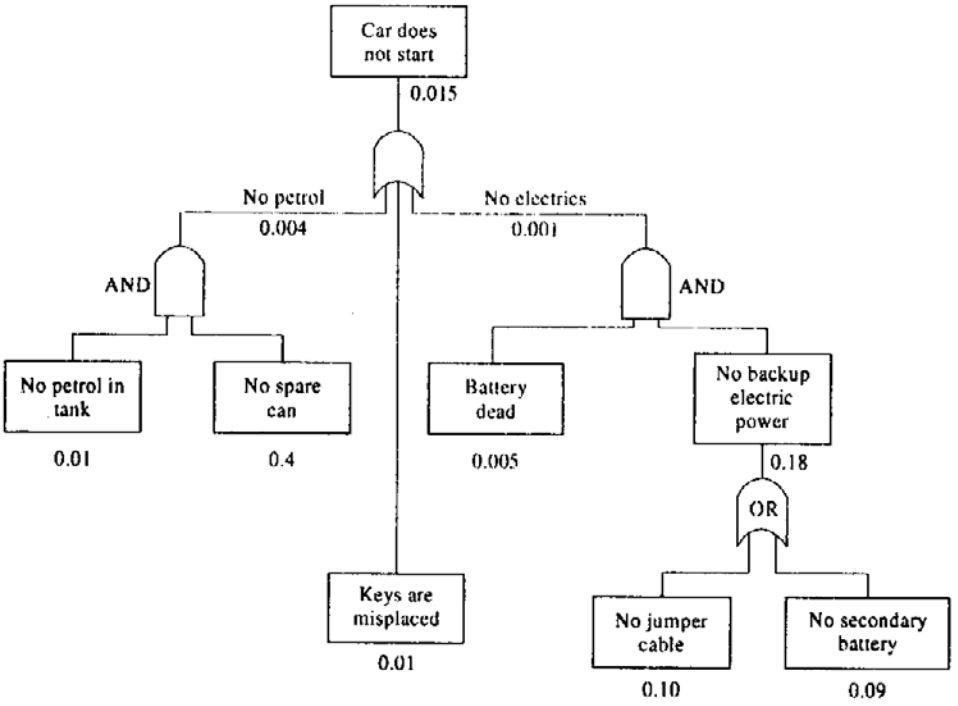

Fig. 4.3 Fault-tree analysis

4. Event-tree Analysis

This method illustrates the sequence of outcomes which may arise after the occurrence of a selected initial event. This method uses inductive logic. It is mainly used for consequence analysis and in identifying the potential hazardous existing situation in the system. It is the inverse of the FTA. FTA allows one to proceed back in time from possible catastrophic accidents to examine the components of sequences with probability of failure. But, the ETA allows the observer to proceed forward in time from potential component failures to final accident.

The most serious outcome such as explosion, toxic release, etc. is selected as the final event. A tree is then constructed by relating the sequences of events, which individually or in combination, could lead to the final event.

Example: Going late for duty

The events are listed, arranged chronologically, and in separate clusters, to include only that are relevant and important. Fig. 4.4 shows the ETA for the event of going late to the office as a simple illustrative example. The branching structure starts with the initiating event (initiator) on the left hand side of the tree and lead to a bad end event (final damaged state) shown at the far right side. The sequence starts with the person getting up late and being time pressed to get to duty.

The person has three alternatives to get there, namely, (*a*) driving his own car along the highway, that is subject to periodic overcrowding and delays while driving, (*b*) to use the public transport (express train or bus), and (*c*) call a coileague and share the car.

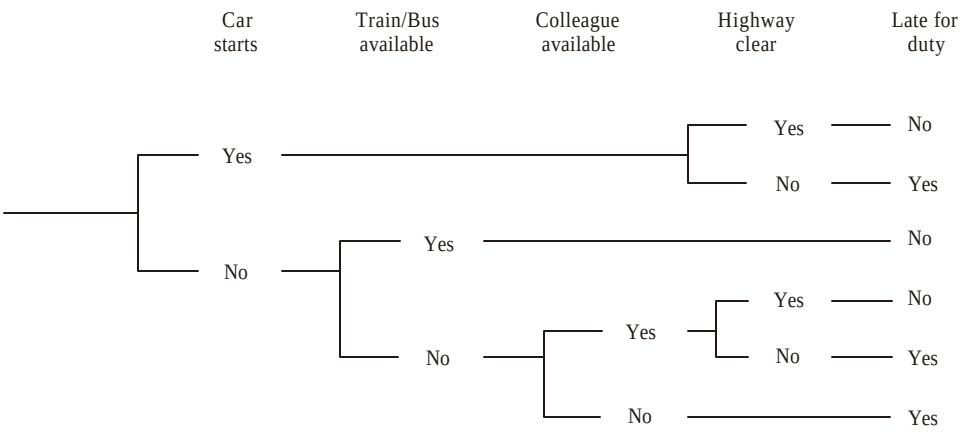

Fig. 4.4 Event-tree analysis

The figure shows the event-tree including the alternatives and different things that could lead to the employee being 'late again'. Alternative outcomes are shown under each column. Trace back from the outcomes towards the left hand side of the tree along horizontal paths. There are series of vertical branches labeled, **Yes** or **No**, which are connected to previous paths. The vertical branches represent the response (Yes/No) to the question (or the systems responsible) that appear on the top of the tree.

Tracing back from first 'No' under 'Late again' one comes to the first label Y/N: Is the highway clear? The up branch represents 'Yes' showing that the highway that morning was clear. The person arrived on time for duty. The down branch representing 'No' means that the highway was not clear and the person was late. This branch is attached to the earlier path and representing the condition that the car did not start. The up branch corresponding to question 'car starts?' indicates 'Yes'. Because car did start, there is no need to consider the backup alternatives of the colleague.

What are the possible outcomes, if the car does not start? Work from left to right starting on the lower "no'' branch for the question 'car starts?'. The next question is train/express bus available? The 'Yes' path goes straight to the outcome of not being late. Notice the questions in the event tree are very simple. We may even ask, is the train sufficiently frequent and are the terminals conveniently located to go to the office in time? Is the day analyzed a holiday with reduced trips? Has there been an accident or breakdown that day, on the line in question?

If the answer is 'No', then we are left with the 'colleague' option, and if he is available and is he willing to offer the ride in time. If not, he will be late. If 'Yes', the question 'Is the highway clear?' must be considered. Heavy highway traffic (Monday morning) may still cause a late arrival.

Remarks

ETA is a variant of FTA that can be used to explore both success and failure alternatives at each level. Event trees are meant to show the path by which we get there. Hence, the event trees are said to have

the memory. The event trees are portrayed in a logical structure that branches from left to right and uses only OR gate. In contrast, a Fault Tree is organized 'top to bottom' hierarchy and uses both AND and OR gates logic. More AND gates a tree contains, the more fault tolerant (and safer) a system typically is. A proliferation of OR gates indicate a failure-prone situation.

Human Error

The human-error contribution to overall system failure can be included in a FTA or ETA, if human-error probabilities are described in the same terms as component and hardware failures. To include human error, a detailed task analysis is first required, listing the actions to be done, conditions, speed of operation and the correct sequencing of individual actions. After allowing for deviations and shaping factors, which influence individual performance (such as skill and stress), and recovery factors (most human errors are recoverable), the contribution of human error can be estimated, by using data on human error rates.

4.2.2 Cost Analysis

A quantitative risk analysis is made on (1) primary costs: the loss of human lives, or property (assets), crops, and natural resources are estimated, and (2) secondary costs: the loss of human capability or loss of earning capacity, cost of treatment and rehabilitation, damage to the property, fertility to the soil, salinity to the groundwater etc. are estimated.

4.3 ASSESSMENT OF SAFETY AND RISK

4.3.1 Uncertainties in Assessment

There are many positive uncertainties in determining the risk of a product/service.

1. Restricted access to knowledge on risk: Some organizations do not disclose the data, citing legal restrictions.
2. Uncertain behavior of materials: Test data supplied by the suppliers are only statistical. The individual parts may behave considerably (! 3 σ) different from the statistical mean obtained from the tests on random samples.
3. Uncertain and varying behavior of user environments such as physical shock, thermal shock, fatigue, creep, impulse and self-excited vibrations in components or structures due to winds, snow fall, and rains cause sudden failure of the whole structure. An error or wrong procedure during assembly or joining the components may cause additional stress leading to early failure.
4. The use or misuse of materials/products, remaining untracked, e.g., exposure to rain or snow or damp weather is likely to change the properties.
5. Newer applications of obsolete technologies, remaining unpublished,
6. Substitution of newer materials whose behavior are not disclosed, and
7. The unexpected and unintended outcomes of the product/project.

All these aspects make the estimation of risk complex and unreliable. Hence, the data are to be monitored continuously and risk estimation updated periodically.

For example, a few friends live very near the cement plant, as they are unable to choose a better location for their house. The group work as motor mechanics in an automobile service station nearby.

The air is full of dust and some drainage canals cut across their house sites. They hold that they are exposed to involuntary risk, from dust and drain. But the same persons have previously-owned motor cycles, with which they travel during week ends to their villages through muddy roads.

Now they are willing to take risk voluntarily, i.e., they have no apprehensions on this travel. Statistical study indicates that individuals are more ready to accept voluntary risks (hunting, skiing, fighting in wars) than the involuntary risks (electric shock, natural calamity). Even though the voluntary risks are thousand times more fatal than involuntary ones, individuals meet them, for the thrill or adrenal quest or for achievement and for a page in the Guinness record.

Another stand or perception closely related to this example is that of 'Control'. There are people who choose to play stunts such as jumping through fire gates, skiing and flying, car racing through tortuous terrains. Most of these people exhibit extraordinary confidence in them and on their gadgets and also believe that the hazards are under their control.

4.4 SAFE EXIT

In the study of safety, the 'safe exit' principles are recommended. The conditions referred to as 'safe exit' are:

1 The product, when it fails, should fail safely
2 The product, when it fails, can be abandoned safely (it does not harm others by explosion or radiation)
3 The user can safely escape the product (e.g., ships need sufficient number of life boats for all passengers and crew; multi-storeyed buildings need usable fire escapes)

4.5 RISK-BENEFIT ANALYSIS

The major reasons for the analysis of the risk benefit are:

1 To know risks and benefits and weigh them each
2 To decide on designs, advisability of product/project
3 To suggest and modify the design so that the risks are eliminated or reduced

There are some limitations that exist in the risk-benefit analysis. The economic and ethical limitations are presented as follows:

1. Primarily the benefits may go to one group and risks may go to another group. Is it ethically correct?
2. Is an individual or government empowered to impose a risk on some one else on behalf of supposed benefit to some body else? Sometimes, people who are exposed to maximum risks may get only the minimum benefits. In such cases, there is even violation of rights.
3. The units for comparison are not the same, e.g., commissioning the express highways may add a few highway deaths versus faster and comfortable travel for several commuters. The benefits may be in terms of fuel, money and time saved, but lives of human being sacrificed. How do we then compare properly?
4. Both risks and benefits lie in the future. The quantitative estimation of the future benefits, using the discounted present value (which may fluctuate), may not be correct and sometime misleading.

5. Both risks and benefits may have uncertainties. The estimated probability may differ from time to time, and region to region.

4.5.1 Personal Risk

Assessing the involuntary personal risk is not an easy task. For example, a group residing near the cement plant is exposed to a lot of risk. If suppose a cement plant or refinery was to come up in the area where this group already reside, they will object the proposal. The adequacy of compensation amount payable can not be fixed reasonably. How to estimate the rupee value of an individual human being? For example, a person may be a father to his young ones, husband to his beloved wife, son to his aged parents, friend to the needy, and as well a guardian for his pet dogs.

There are persons who dared to serve people in dire straits, in spite of the risky situations where their lives were in stakes. For example, Mahathma Gandhi served people during Navakali yatra, when dangers were present all over. For such saviors, there was no personal risk.

However, any of the following methodologies may be adopted to assess quantitatively, the personal risk:

1. Assess the voluntary activities (e.g., life insurance policy taken)
2. Assess the degree of occupational hazard (e.g., dust, radiation, and asbestosis) and its effect on health.
3. Loss of senses such as sight (eyes), hearing (ears) and loss of limbs (immobility by the loss/ damage to organs or disfigurement of the limbs or body).
4. Loss of earning capability, especially due to physical disability, and
5. Get assistance by trained arbiters.

4.5.2 Public Risk

Assessing the public risk is relatively easy, as in the societal value system the cost of disability can be averaged out. For example, the U.S. National Safety Council 1 adopts an equivalent of 6000 days (16.42 years), for death, as per the personal value system for social costs of disability.

To assess the public risk, the loss on the assets and the correction costs are estimated. For example,

1 Loss of or reduction in future income or earning capacity due to loss of limbs or their capability
2 Costs associated with accident , which includes the transplantation or reinforcement of body parts/limbs, and medical treatment and
3 Cost of welfare, which includes rehabilitation, provision of less-demanding alternate jobs, and other disability benefits.

4.5.3 Reducing Risk (Improving Safety)

Several techniques adopted to reduce the risks (or improve safety) in a product or process are listed as follows:

1. Application of inherent safety concepts in design, e.g., LPG cylinder is provided with frame to protect the valve while handling and facilitate cryogenic storage. A magnetic door catch provides an easy escape for children caught inside the 'fridge' accidentally.
2. Use of redundancy principle in the instrument protection/design. For example, use of stand-bye device, and back-up for computer storage.

3. Periodical monitoring (inspection) and testing of safety system to ensure reliability, e.g., fire extinguishers, 'earth' system in electric circuits are checked periodically.
4. Issue of operation manuals, training of the operating personnel and regular audits are adopted to ensure that the procedures are understood, followed and the systems are kept in working condition.
5. Development of well-designed emergency evacuation plan and regular rehearsal/drills to ensure preparedness, in case of emergency.

4.5.4 Voluntary Risk

Voluntary risk is the involvement of people in risky actions, although they know that these actions are unsafe. The people take these actions for thrill, amusement or fun. They also believe that they have full control over their actions (including the outcomes!) and equipments or animals handled, e.g., people participate in car racing and risky stunts.

Testing becomes inappropriate when the products are

1 Tested destructively
2 When the test duration is long, and
3 When the components failing by tests are very costly. Alternate methods such as design of experiments, accelerated testing and computer-simulated tests are adopted in these circumstances.

4.6 SAFETY LESSONS FROM 'THE CHALLENGER'

The safety lessons one can learn in the Challenger case are as follows:

1. Negligence in design efforts. The booster rocket casing recovered from earlier flights indicated the failure of filed-joint seals. No deign changes were incorporated. Instead of two O-rings, three rings should have been fixed. But there was no time for testing with three rings. At least three rings could have been tried while launching.
2. Tests on O-rings should have been conducted down to the expected ambient temperature i.e., to 20 ^{O}F. No normalization of deviances should have been allowed.
3. NASA was not willing to wait for the weather to improve. The weather was not favorable on the day of launch. A strong wind shear might have caused the rupture of the weakened O-rings.
4. The final decision making of launch or no-launch should have been with the engineers and not on the managers. Engineers insisted on 'safety' but the managers went ahead with the 'schedule'.
5. Informed consent: The mission was full of dangers. The astronauts should have been informed of the probable failure of the O-rings (field joints). No informed consent was obtained, when the engineers had expressed that the specific launch was unsafe.
6. Conflict of interest (Risk Vs. Cost): There were 700 criticality-1 items, which included the field joints. A failure in any one of them would have cause the tragedy. No back-up or stand-bye had been provided for these criticality-1 components.
7. Escape mechanism or 'safe exit' should have been incorporated in the craft. **McDonnell**

Douglas, the engineer, designed an abort module to allow the separation of the orbiter, when triggered by a field-joint leak. Unfortunately such a 'safe exit' was rejected due to the increase in the cost, simultaneously with reduction in payload.

8. Ethical engineers should have been given awards and encouraged to hold their discretion (moral autonomy) in risky situations, and to report to appropriate agency their views, in the interest of public safety.

4.7 CASE STUDY: POWER PLANTS

4.7.1 Three-mile Island

The TMI nuclear Power Plant Unit 2 is located in a river basin in Pennsylvania, USA (March 28, 1979, 4 a.m.)

The nuclear power plant had a Pressurised Water Reactor system (PWR). The main reactor core (1) release heat which is transferred to water in the primary circuit (1-2-3-4). The heat from the steam generator (3) is transferred to water in the secondary circuit (7) at low pressure. The water in the secondary circuit gets converted into steam in the boiler (3). This steam flow drives the turbine (8), and the exhaust stem is converted into water in the condenser (10) and circulated back into the boiler (3) by means of pumps (11,13,14) (Fig. 4.5).

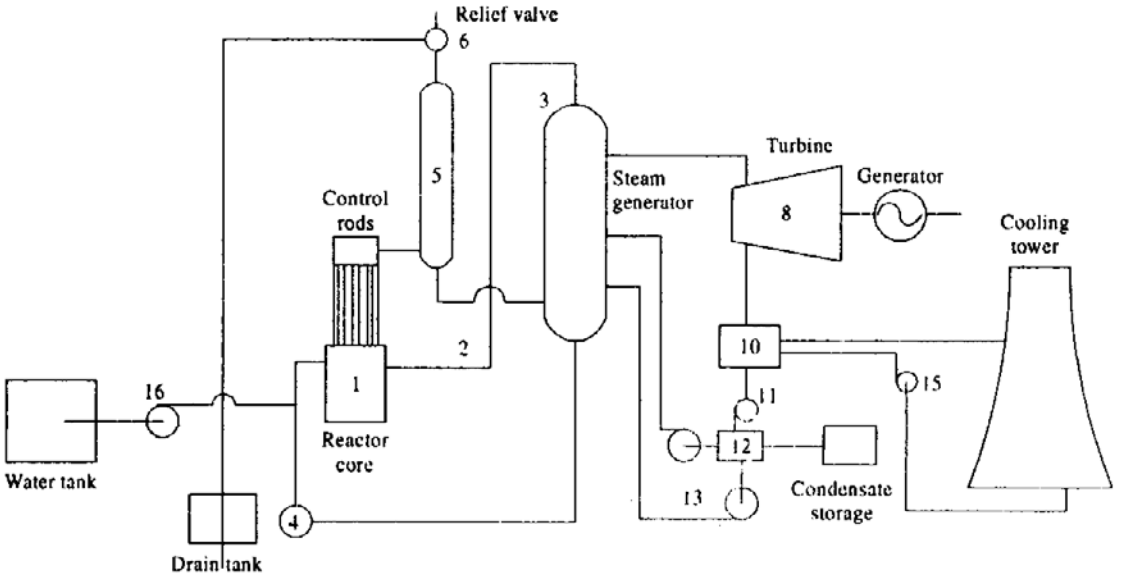

Fig 4.5 System components of TMI - 2 plant

The demineraliser (12) contains resin beads to clean condensate. A problem in the demineraliser arose and this led to the closure of the outlet valve of (12) to the steam generator (3). This resulted in shut down of main feed water pump (13) and the auxiliary feed water pump (14) failed.

The reactor pressure increased to very high level, opened a pressure relief valve (6) and gave a signal (SCRAM), which helped to lower the control rods in the reactor core, in order to stop the main fission process. This valve (6) remained opened for long.

When pump (14) failed, the steam generator (3) went dry. So, heat was not removed from the reactor. Water was pouring out at 220 gallons/min but reactor has not cooled down.

Pumps (16) were started to refill water reactor core. There was too much of water in the reactor now. The reactor fuel rods began to break to pieces.

Then the chemical reaction between steam and the Zinc alloy fuel elements produced Hydrogen and the Hydrogen accumulated caused the explosion of the structure.

The radiation levels in the building increased and the sound alarm blew. Immediately people contacted Nuclear Regulatory Commission and B and W, who constructed the reactor. Nobody was there to answer the call at B and W. But somehow people escaped without any loss of human lives.

After 13 hours and a half, the reactor was put under control.

4.7.2 Chernobyl, Near Kiev, Russia (April 1986)

The RBMK (Acronym for water cooled and graphite moderated) reactors were graphite moderated and they use water tubes. A test on the turbine generator was planned to be conducted during a scheduled plant shut-down maintenance.

To conduct the test, the power plant output was reduced to 700 MW. But due to a sudden and unexpected demand, the power output has to be raised.

1. To go ahead with the test, the reactor operators had already disconnected the emergency core-cooling system, ignoring the raise in demand situation.
2. Further, a control device was not properly reprogrammed to maintain power at 700-100 MW level
3. The test was conducted at 200 MW power out-put which is very low for the test. They should have shut down the reactor.
4. The operators blocked all emergency signals and automatic shut-down controls, thus all safety systems were disconnected.
5. The operators raised control rods to increase power output and tried to continue the test. This made the reactor unsafe. The temperature of RBMK reactor increased and the fission rate increased.
6. The test should have been postponed but continued. The reactor core melted and due to the Hydrogen accumulation, the reactor caught fire and the radioactive waste began to spread out in USSR and also Europe.

The people living around were informed after a few hours and were evacuated 12 hours after the explosion. More than 30 workers in the complex lost their lives, while 200 workers sustained burns. About 8000 people lost their lives. The agricultural products were affected due to contaminated radioactive water, for several years.

4.7.3 Safety Lessons From TMI and Chernobyl

1. The thickness of the containment should be more, to withstand the possible explosion and further damage due to radiation and leakage over the surroundings (Chernobyl).
2. When the test began at low loads, the demand for increased outpower should have been declined.

3. Or the tests should have been abandoned and all controls switched on. Then the output should have been increased (Chernobyl).
4. The decision making on test and increase the load should have been with one person or the decision makers should have coordinated with each other (Chernoby1).
5. Valves are the least-reliable components in the hydraulic system. Such a malfunction of the pressure relief valve and lack of information about its opening (or closing) were reported elsewhere in the past. But there was no 'learning from the past' (TMI).
6. Continuous monitoring of the components such as demineraliser and the pressure operated relief valve must have been made (TMI).
7. A comprehensive precursor program (emergency procedures) should have been implemented to record a few accident sequences and map these events to risk models. The mapping based on technical and human factors give us accounts, how people react and interact under conditions of stress (TMI).
8. Periodical mock drill of emergency for the operators (safe exit) should have been arranged (TMI and Chernoby1).
9. In-stack radioactivity monitoring instrument indicated a rise earlier. The operators at TMI 2 should have informed the superiors at once. People residing in the neighborhood ought to have been informed and steps initiated to evacuate the public immediately (TMI especially, and also Chernobyl).

4.8 COLLEGIALITY AND LOYALTY

4.8.1 Collegiality

Collegiality is the tendency to support and cooperate with the colleagues. It is a virtue essential for the team work to be effective. This consists of various aspects such as:

1. *Respect to the ideas and work of others*: This results in support and co-operation with one's colleagues. One gets back the support and cooperation in return, and this is mutually beneficial.
2. *Commitment to moral principles*: Commitment is towards moral decisions, actions, goals of the organisation and values of the profession.
3. *Connectedness*: It means the shared commitment and mutual understanding. It ensures the absence of egoism and paves way for progress for both.

4.8.2 Loyalty

Loyalty is exhibited in two senses, namely,

1. Agency Loyalty

It is an obligation to fulfill his/her contractual duties to the employer. The duties are specific actions one is assigned, and in general cooperating with others in the organization. It consists of several obligations to employers. But, for the engineers, the paramount obligation is still "the safety, health, and welfare of the public"

2. Attitude Loyalty (or Identification loyalty)

It is concerned with the attitudes, emotions, and a sense of personal identity. It includes willingness to meet moral duties, with attachment, conviction, and trust with employer. The attitude loyalty is more a virtue than an obligation. This type of loyalty is all right when the organizations work for productivity or development of community. Working together in falsification of records or serious harm to the public, does not merit loyalty. Further, with frequent takeovers or merger resulting in large-scale lay-off, employees find it difficult to maintain attitude-loyalty.

4.8.3 Authority

Decisions can be taken by a few people, but putting into action requires larger participation from different groups of people, such as operation, purchase, sales, accounts, maintenance, finance etc. In effectively-and efficiently-transferring decisions to actions, the authority comes into play a great role. Otherwise the individual discretions may ruin the activities. Further the authority fixes the personal responsibility and accountability uniquely on each person. This is necessary to ensure progress in action.

Institutional Authority

It is the authority exercised within the organization. It is the right given to the employees to exercise power, to complete the task and force them to achieve their goals. Duties such as resource allocation, policy dissemination, recommendation, supervision, issue orders (empower) or directions on sub-ordinates are vested to institutional authority, e.g., Line Managers and Project Managers have the institutional duty to make sure that the products/projects are completed successfully. The characteristics features of institutional authority are that they allocate money and other resources and have liberty in execution.

Expert Authority

On the other hand, the Expert Authority is (*a*) the possession of special knowledge, skills and competence to perform a job thoroughly (expertise), (*b*) the advice on jobs, and (*c*) is a staff function. It is also known as ‘authority of leadership’. These experts direct others in effective manner, e.g., advisers, experts, and consultants are engaged in an organization for a specific term.

4.9 COLLECTIVE BARGAINING

It is the bargain by the trade union for improving the economic interests of the worker members. The process includes negotiation, threatening verbally, and declaration of ‘strike’. It is impossible to endorse fully the collective bargaining of unions or to condemn. There exist always conflicting views between the professionalism and unionism.

A. Faithful Agent or Trustee?

Professional societies such as NSPE and IEI refuse to accept the ‘collective coercive action’ of unionism, holding the principles of professional integrity as right, e.g., as per NSPE code III, i.e., engineers shall not promote their own interest at the expense of the dignity and integrity of the profession. The

engineers are said to exhibit a higher standard than self-interest; and they are expected to perform an ethical duty to their employer as faithful agent or trustee. The actions of unions are usually against the interests of the employers and they use coercion and force against the employers. These actions are interpreted as unprofessional and disloyal. But in certain cases, the safety of the workers had been ignored for a long period or the employees were under-paid for years. Can we still hold the action as unethical?

It can be concluded from this discussion, that

(*a*) The duty of the employee to one's employer does not mean sacrifice of monetary self-interests, and

(*b*) trustee or faithful agent means executing the assigned tasks and safeguarding the property. It does not nullify the right to negotiate for safe and hygienic working conditions, and economic benefits collectively.

(*c*) The codes insist that the paramount obligation is to the society, as compared to their employers. The duty to the employers is also limited by considerations such as workers safety, and the right to disobey illegal or unethical activities. After all the employees are also parts of the society, and

(*d*) Can collective and coercive action be resorted, when all other efforts have failed?

B. Service to the Public?

The service to the public is of foremost importance. But the unions promote the interests of a few members only. The public welfare should not suffer because of their actions. Imagine a situation when all the teachers, medical practitioners, and ambulance drivers go on strike. Will this not cause damage to the public safety and health?

Collective bargaining by engineers through union or association or forums may act within limits set by the concern for the public welfare. Professional societies can play a great role in the promotion and establishment of principles and practices towards fair employment and exploitation. But they can not function as collective bargaining agents.

The collective bargaining can not be judged as unethical, unless we study the cases individually and decide. The collective bargaining is acceptable per se, but the means should be constructive, persuasive, firm based on mutual understanding, and not destructive, disruptive, and not harming the persons or property.

C. Assessment on Unionism

The moral assessment on Unions is a complex process. A careful consideration of all relevant moral facts are to be inquired into and judged. It can not be generalized, because of the divergent views on unionism, as shown in Table. 4.1.

Table. 4.1 Pro- and anti-views on unionism

For unionism	*Against unionism*
1. Unions have been useful in improving the standard of living and economic benefits of the workers. Even non-union members leading to inflationary condition are able to get those benefits.	1. Unions have lead to disturb the economy of state by salaries, and increase salaries and expenses, leading to inflationary conditions.
2. Unions have obtained greater participation in organization, by participative management. Union members are appointed as Directors in the Board and credited to act as bridge between the employers and employees.	2. Instead of being cooperative, they act in negative and destructive ways, causing loss of man-days. Opinions of the individual worker is suppressed and used as pawns.
3. Unions have contributed to the job security, and protection against arbitrary treatment to the employees.	3. Unions encourage mediocrity, and act in favor of seniority-based promotion. Merit-based promotion and awards for personal achievement are disregarded
4. They are able to put resistance to unethical orders and support to ethical actions	4. Unions thrive on prolonged unrest, dissatisfied, and tense relations between workers and management.
5. They have provided for effective grievance redressal mechanism for employees.	
6. They act to safeguard against the possible political interference, exploitation, and alienation in the company affairs.	5. They cause pigeon-holing of employee in narrow job classifications to which the salary scales are attached.

4.10 CONFIDENTIALITY

Confidentiality means keeping the information on the employer and clients, as secrets. It is one of the important aspects of team work.

4.10.1 Justification for Confidentiality

Confidentiality can be justified by various *ethical theories*. According to Rights-based theory, rights of the stakeholders, right to the intellectual property of the company are protected by this practice. Based on Duty theory, employees and employers have duty to keep up mutual trust. The Utilitarian theory holds good, only when confidentiality produce most good to most people. Act utilitarian theory focuses on each situation, when the employer decides on some matters as confidential.

Further, the following *moral principles* also justify the concept of 'confidentiality':

1. Respect for Autonomy

It means respecting the freedom and self-determination of individuals and organizations to identify their legitimate control over the personal information of themselves. In the absence of this, they can not keep their privacy and protect their self-interest.

2. Respect for Promises

This means giving respect for the promises made between the employers and employees. Employees should not disclose the promises given to the employers. This information may be considered as sensitive by the employer. But promises do not establish complete obligations.

3. Trustworthiness

Maintaining confidentiality by lawyers, accountants, and attorneys are necessary to develop confidence and welfare of the individuals and the organizations. It does not mean however that these professionals collude with them unethically.

4. Respect for Public Welfare

This moral consideration is important in identifying relationships in professional transactions, for the benefit of public welfare, e.g., if the medical practitioners keep confidentiality on the problems of patients, patients develop confidence and trust in them, they feel free to reveal their problems and personal information, without being shy. This is likely to increase their chances of being cured. Similarly, a company keeping confidentiality about its products gets economic benefits of competitiveness. Besides, the public are also benefited from a healthy competition. An attorney keeping the data on clients confidential, provide safety and welfare of the clients as well as the public.

4.10.2 Types of Confidential Information

On the basis of *acquisition (possession),* the confidential information are divided into two types, as follows:

1. Priveleged Information

It is information that is available and accessed, by virtue of a privilege, i.e., privilege of being employed on that assignment. The security check is also insisted during exit from the work place against the leakage of this type of information. An engineer working on defense project may know that the missile he has developed is to be tested against the terrorists across the border.

2. Proprietary Infromation

It is the information *owned* by the organization. It refers to the knowledge and procedures established by and in the organization. Some internal communication in an organization is marked as 'proprietary'. It is protected legally by the organization from use by others, including the employees. The trade secret is proprietary information that has not been made public. A limited legal protection is available for this proprietary information by common law, which prevents employees from disclosing it to outsiders. The *quality manual* is another example for proprietary information.

On the basis of *severity* of risk from breach, the confidential information is divided as:

1. *Obvious information*: It refers to data, information, and test results on the products yet to be released, or designs, formulae, and technical processes of the products. The risk or loss from the breach is large and may threaten the survival.
2. *Information of lesser confidentiality*: This relates the business information such as the number of employees working on projects, the identity of vendors or suppliers, customers, marketing strategies, yield of manufacture, cost of manufacture, substitution of materials etc. The risk

or loss involved is relatively less. In competitive business situations, this information also plays a vital role.

4.10.3 More on Confidentiality

A. Is Switching Job Ethical?

When persons change jobs (employers), what happens to their moral obligation? The obligation to protect the information does not cease, when one shifts to another employee. Otherwise, the former employee will reveal this information to the new employer or sell it to a competitor of the former employer. The integrity of the employee, even upon switching the employer demands that he maintains confidentiality and does not to divulge the information. The professional integrity of engineers is more valuable than the loyalty to the current employer.

Many engineers value professional advancement than long-term tie and loyalty to a single employer. The engineers involved in research and development and expert contribution change jobs. Normally they are familiar with the innovative developments in the parent organizations. For example, one manufacturing expert along with his colleagues as well as with some secret documents left General Motors and joined Volkswagen. This violation of trade secret, lead the V W to pay huge compensation to GM in cash and compulsion to buy parts from GM for seven subsequent years.

Employees, who change jobs, will not able to withhold their knowledge and expertise. They are sought after only for their expertise. They may not carry the papers and but their active brain always carry memories. Although some organizations hold that this is unethical, the individuals can not be prevented from divulging the facts to benefit the current employer. The courts have held a moral verdict. Even though the previous employers had the right to maintain their trade secrets confidential, the personal rights of the employees, who switched job in pursuit of career advancement, had to be honored and balanced.

B. Management Policies

How can we protect the rights of the employers and at the same time recognize the genuine personal rights and other rights of the engineers/employees? Some of the management practices and their limitations are discussed hereunder:

1. One way is to restrict the future employment of employees, by using employment contracts at the time of their exit. Details such as the restriction on geographical location, time gap between the departure from one place and engagement with the other employer, and on the type of jobs that one can perform with future employer, are entered in to contracts. But such contracts have not been given legal sanction.
2. An incentive instead of threatening their rights by the employment contract, may offer some positive benefits in exchange for the restrictions listed. A lump sum post-employment payment or compensation over a specific period may offered as incentive to restrict him.
3. Another approach by the management is to effect tighter controls on internal information flow on trade secrets and other vital features. But this is likely to create a mutual distrust in the organization and to throttle the creativity of engineers involved in the research and development.

A better understanding between the ethical management and the professional responsibility of the engineers will fulfill both professional concerns and employee loyalty.

4.11 CONFLICT OF INTERESTS

A conflict of interest occurs when the employee has more than one interest. A professional conflict of interest is the situation where the professional has an interest that, if pursued, might prevent him from meeting his obligations to his employers or clients, e.g., an Electrical Engineer working in the State Electricity Board may have a financial interest in a company which supplies electrical instruments. If the engineer is decide on the bid for the supply of electrical instruments, a clear case of conflict of interest exists.

A 'conflict of interest' is different from 'conflicting interests'. A student has to clear four arrears subjects in the supplementary examination. But he finds that the time available is sufficient to study only three subjects. This is a situation of 'conflicting interests', where he has two or more desires that can not be fulfilled under the given circumstances. But there is no moral problem involved in pursuing all subjects. In case of professional conflict of interest, there is a possibility of pursuing all the conflicting interests, thereby inviting a moral problem.

4.11.1 Types of Conflicts of Interest

Several types of conflicts of interests exist depending on the ways and severity of outside interests. A few common types are discussed here.

1. Actual Conflict of Interest

This refers to the situation where the objectivity is lost in decision making, and the inability to discharge the duty to the employer. It is the result of weaker judgment and service. A Civil Engineer working in the Public Works Department has a financial interest in a contracting company, which has submitted a bid for the construction of a bridge. There may be a variety of outside interests. But the conflict arises when the outside interest influences or threatens the professional judgment in serving the employer or clients.

2. Apparent Conflict of Interest

This is explained in the following example. An engineer is paid based on a per cent of the cost of the design and there is no incentive for him to cut the costs. In this situation, it appears that the engineer makes the design more expensive in order to get larger commission for him. This situation leads to doubting the engineer's interest and ability for professional judgment.

3. Potential Conflict of Interest

There are situations where the interest of an employee extends beyond the current employer and into the interest on one's spouse, relative or friend. The interest changes into intimacy and subsequent non-moral judgments against the interest of the employer and in favor of the outsider or even a potential competitor.

(*a*) Favorable Contact

When an engineer's spouse is working for a contractor or vendor, a conflict does not arise. But if the engineer is to give a subcontract to the contractor or purchase order to the supplier, the conflict arises. This happens even when the engineer has partial or substantial stockholding in the business of that contractor or supplier.

(*b*) Bribe and Gift

The conflict arises when accepting large gifts from the suppliers. Bribe is different from a gift. The following table shows a comparison of the nature of bribe and gift.

Table 4.2 How does bribe differ from gift?

Tests	*Bribe*	*Gift*
1. Timing	Given before	Given after
2. Cost of item	Large amount	Small amount, articles of daily use
3. Quality of product	Poor	Good/High
4. Giver is a friend	Yes	No
5. Transparency	Made in secret	Made in open
6. Motive	Expect undue favor	Expect a favor or thanking for the favor
7. Consequence on organization's goodwill	Damaging the goodwill and reputation	No damage is involved

Codes of ethics do not encourage even gifts, but employees have set forth flexible policies. Government and company policies generally ban gifts more than a nominal value (>Rs.1000?) An additional thumb rule is that the acceptance of gift should not influence one's judgment on merit.

(*c*) Moonlighting

It is a situation when a person is working as employee for two different companies in the spare time. This is against the right to pursue one's legitimate self-interest. It will lead to conflict of interests, if the person works for competitors, suppliers or customers, while working under an employer. Another effect of moonlighting is that it leaves the person exhausted and harms the job performance in both places.

(*d*) Insider Information

Another potential conflict of interest is when using 'inside' information to establish a business venture or get an advantage for oneself or one's family or friends. The information may be either of the parent company or its clients or its business partners, e.g., engineers might inform the decision on the company's merger with another company or acquisition or an innovative strategy adopted. In such cases, their friends get information on stock holding and decide on trading their stocks to sell or buy quickly, so that gain more or prevent a loss. For example, in WorldCom USA, the insider information was used to manipulate and sell a large amount of stock holding by the Director, upon knowing that the government has declined to admit their product.

4.12 OCCUPATIONAL CRIME

An occupational crime may be committed by (1) wrong actions of a person through one's lawful employment or (2) crime by an employee to promote ones own or employer's interest or (3) theft or

pilferage by the employee or (4) damage to the property or an employee of one's organisation. These are also called *white-collared crimes.*

Many of these crimes are examples of conflicts of interest. These are motivated by the greed, corporate ambition, and misguided loyalty. Even the crime to promote the interests of the employer, is an occupational crime. Some of the examples of occupational crimes are:

1. *Price Fixing*

Fixing the bidding rate by companies, in collusion with other companies, especially for the contract/services, is called *price fixing*. This is an occupational crime, prevalent in electrical equipments industries, where there used to be a few contractors but large number of contracts. Because of this, public as well as the government incur huge loss. Two top officers of Westinghouse and GE, USA who were involved in price fixing without the knowledge of their Directors, were sentenced to imprisonment a few years back. These officers held that it was legal to fix price and even argued that this procedure is really beneficial to the people! However, the court did not accept this view.

2. *Industrial Espionage*

It means simply spying for personal or company benefits, e.g., in the Silicon Valley area, there are several company manufacturing computer chips, ICs, and microprocessors. There are a lot of engineers who are entrepreneurs and venture capitalists. The espionage is more prevalent here because of the following factors:

(*a*) The development of chips is extremely competitive and on fast track. Profit and loss can be made quicker.

(*b*) Manufacture of chips is very costly. Huge saving through reverse engineering could be made only by breaking open the competitors' gadgets or fast tests. Some organizations prefer to steal the design details through illegal means rather testing and development.

(*c*) The components involved are very small. Hence, pilferage or removal of gadgets could be done easily and without being caught.

(*d*) The crime detection and law enforcement are difficult and ineffective.

(*e*) Employees do not carry out the activities directly, but through engineers who were employees or through the weakest link in the supplier-producer chain.

3. *Bootlegging*

Manufacturing, selling or transporting products (liquor and narcotics) that are prohibited by law, is called *bootlegging*. In engineering context, it refers to working on projects which are prohibited or not properly authorized.

4. *Endangering Lives (Occupational Hazards)*

Industries who expose their employees to hazards usually escape penalties. Victims have the right to sue, but only to claim some monetary compensation. The *asbestos* industries in USA were responsible for the death of one lakh workers and 27 million workers afflicted with cancer, in the 80s. Even after 22 years since Bhopal gas tragedy, appropriate compensation has not been paid. Even the government could not bring to book the culprits for the crime committed.

Occupational Health and Safety Assessment Series, OHAS-18001 Certification has been adopted in many Indian Industries. As per the Annual report of RIL[10], an initiative called Project CASH, Change Agent for Safety and Health, had been formed to bring about a positive change and continual improvement in occupational health practices at the work place, besides attitudinal and behavior changes. This is claimed to have prevented work-related diseases, injuries, reduced absenteeism, and ultimately increased the productivity level.

4.13 HUMAN RIGHTS

Human rights are defined as moral entitlements that place obligations on other people to treat one with dignity and respect. Organisations and engineers are to be familiar with the minimum provisions under the human rights, so that the engineers and organizations for a firm base for understanding and productivity. Provisions under 'human rights' are as follows:

1. Right to pursue legitimate personal interest
2. Right to make a living
3. Right to privacy
4. Right to property
5. Right of non-discrimination
6. No sexual harassment

Under professional rights, the following provisions are protected:

1. *Right to form and express professional judgment*: It is also called the *right of professional conscience*. In pursuing professional responsibilities, this empowers one to form and exercise the professional judgment. Both technical and moral judgments are included. This right is bound by the responsibilities to employers and colleagues.
2. *Right to refuse to participate in unethical activities*: It is also called the *right of conscientious refusal*. It is the right to refuse to engage in unethical actions and to refuse to do so solely because one views that as unethical. The employer can not force or threaten the employee to do something that is considered by that employee as unethical or unacceptable. For example, unethical and illegal activities that can be refused are: falsifying data, forging documents, altering test results, lying, giving or taking bribe etc. There may be situations, when there is a disagreement or no shared agreement among reasonable people over whether an act is unethical. Medical practitioners have a right not to participate in abortions. Similarly, the engineers must have a right to refuse assignments that violate their personal conscience, such as when there exists a threat to human life or moral disagreement among reasonable people.
3. *Right to fair recognition and to receive remuneration for professional services*: Engineers have a right to professional recognition for their work and achievements. This includes fair monetary and non-monetary forms of recognition. It is related to morality as well as self-interest. They motivate them to concentrate their energy on jobs and to update their knowledge and skills through continuing education. This will prevent the engineers from diversion such as moonlighting or bother on money matters. Many times, the engineers who have labored to get patents on the organizations are not adequately remunerated. Based on the resources of the organization and the bargaining power of the engineers, the reasonable salary or remuneration for patent discovery can be worked out.

4. *Right to warn the public about dangers*: It should be done without damaging the reputation of the employer. The views can be expressed through the professional society to get a backing.
5. *Right to talk publicly about the job*: This should be done within the limits of decency, confidentiality, and loyalty.
6. *Right to engage in the activities of professional societies*: Attending membership campaign and seminars are typical activities to promote the professional society.

4.14 EMPLOYEE RIGHTS

Employee rights are the moral and legal rights that are obtained by the status of being an employee. The provisions made to the employees under this category are:

1. Professional rights (discussed already)
2. Basic human rights (discussed already)
3. Institutional rights or contractual employee rights. This include the rights to the institution due to the organisational policies or contracts, right to receive specified salary and annual increments, and profit sharing. The quantum of such benefits, scale of pay etc. are fixed and reviewed periodically by the employers and employees.
4. Non-contractual employee rights: These are the rights provided in common, besides the contractual ones. They include:

1. *Right to Privacy*

It is the right to control the access to and use of information about oneself. This right is limited in certain situations by employers' rights. But who among the employers can access the personal information is again restricted. Only duly authorized persons can get the personal information.

For example,

(*a*) The Pay Bill Section can access the information on insurance premium paid, medical reimbursement etc. but one's immediate boss need not get this data.

(*b*) Persons who have applied for the jobs of cashier are required to report if there are any criminal or civil cases pending against them. Those persons may mishandle the money. Hence, that information may be sought from them.

(*c*) A supervisor might suspect a worker and conduct a search in his cupboard when the worker is absent. But the supervisor is to have another officer as witness, in such cases. Otherwise the supervisor may plant-in some evidences against the worker.

(*d*) Upon frequent pilferage reported from the stores, the company may install surveillance cameras or bugging devices to monitor personal conversations, without notifying the employees. Prior notice to the employees on the intentions of such a step along with the proposed date of implementation should have been communicated to all concerned.

2. *Right to Choose Outside Activities*

This is also interpreted as a right to personal privacy as that means a right to have a private life outside the job. There are some situations when this right can be curbed. For example,

1. When those activities lead to violation or found detrimental to the duties of their job.

2. When the activities of the employees form a conflict or interest (e.g., when moonlighting).
3. When the interest of the employer is getting damaged (if the employee transfers some vital information on plans or strategies to the competitor).

3. *Right to Due Process from Employer*

It is the right to fair process or procedures in firing, demotion and in taking any disciplinary actions against the employees. Written explanation should be initially obtained from the charged employee and the orders are given in writing, with clearly-stated reasons. Simple appeal procedures should be framed and made available to all those affected. Fairness here is specified in terms of the process rather than the outcomes.

4. *Right to Equal Opportunity—Non-discrimination*

Discrimination because of caste, sex, religion, creed, and language are regressive actions. Discrimination which means a morally unjust treatment of people in the workplace is damaging to the human dignity. For example,

(*a*) A senior manager post is vacant. There is competent and proven candidate from outside the state. A local engineer with lesser competence is promoted.

(*b*) Prize amounts for the winners in the world sport events are not the same for men and women.

5. *Right to Equal Opportunity—Sexual Harassment in the Workplace*

The sexual harassment is a display of arrogance and misuse of power through sexual means. It is against the moral autonomy i.e., freedom to decide on one's own body. It is also an assault on one's human dignity and trust.

Sexual harassment may be defined as the unwanted compulsion or attack on sexual requirements (gratification) in the context of unequal power. It includes physical as well as psychological attack or coercion and indecent gestures by men shown on women or by women on men. Two such forms of harassment are found to exist. In one type called 'exchange of favors', senior officers demand sexual favor as a condition for giving a job, or granting a promotion or increment. It may be either in the form of a physical or verbal threat or sexual offer. In another type called 'hostile work environment', it is the sexually-oriented work environment that threatens the employee's right to equal opportunity. Undesirable sexual proposals, advances, lewd remarks, mailing obscene photographs are some of the typical examples of this type of harassment.

A rights ethicist interprets this as a serious violation of human right to pursue one's job free from extraneous force, compulsion, punishment or threat or insult. A duty ethicist would call it as a blatant violation of duty to treat human being with dignity and individual freedom, and not to treat as inanimate object for immoral gratifications. The utilitarian would expose the effect on the happiness and the welfare of the victims, especially of women.

6. *Right to Equal Opportunity—Affirmative Action or Preferential Treatment*

It means giving a preference or advantage to a person of a group that was denied equal treatment in the past. Such treatments are given especially to women and minorities all over the world. It is also called 'reverse preferential treatment', because it reverses the historical preferences.

There are arguments in favor of as well as against such treatments, all over the world. Table 4.3 presents a comparison of these views.

Table 4.3 Pro- and against-preferential treatments

In favor of preferential treatment	*Against reverse preferential treatment*
1. Compensatory justice: Violations of rights in the past must be compensated. Usually this treatment is extended to all in the group rather than individuals. 2. Racial and sexual violation and violence still exist today. To counterbalance this, the reverse preferential treatment is necessary to ensure equal opportunity to minorities and women. 3. It has produced desirable consequences It has raised the social and economic status and provided them role models and have promoted self-esteem.	1. It violate the rights to equal opportunity for majority, to compete on merits. 2. Compensation may be given only to specific individuals and not for all. 3. Provide special funding and education for the disadvantaged. But jobs should not be used as a compensatory tool. 4. Reduces the productivity, as the merit is the casualty. Self-doubts and indecision affect others' morale and efficiency.

A compromising stand is to permit reverse preferential treatment within organizations, where the bias against women and minorities existed. Alternatively, the weak form of reverse treatment instead of the strong form, may be accepted.

For example, in India, the admissions and employment in government organizations and all educational institutions are given on the preferential (community quota) basis, namely scheduled, backward and most backward castes etc. The article 15(5) of the Constitution effective from January 20, 2006, provides for the advancement of socially- and educationally-backward classes of citizens in matters of admission—including reservation of seats. The reservation in state-run educational institutions including I.I.T.s and I.I.M.s is planned to be fixed at 22.5% for Scheduled Castes and Tribes and 27% for the other backward classes, from June 2007 onwards.

This is being suggested for implementation in the private organizations also. But the Indian private sector and multinational organizations and industries prefer to follow the system of affirmative action where the deprived are raised to required levels of competence.

4.15 WHISTLE BLOWING

4.15.1 Definition

Whistle blowing is defined as conveying information by an employee, on an important moral problem to somebody in a position to take action on the problem. Further, this is done outside the approved organizational channels.

4.15.2 Aspects

There are four aspects of whistle blowing, namely:

1. *Basis of disclosure*: The basis for disclosure may be intentional, or under pressure from superiors or others not to disclose.
2. *Relevance of topic*: The whistle blower believes that the information is about a significant problem for the organization or its business ally. It can be a threat to the public or employees' health, safety and welfare or a criminal activity, or unethical policies or practices, or an injustice to the workers within the organization.
3. *Agent*: The person disclosing the information may be a current or former employee or a person having a close link to the organization.
4. *Recipient*: The person or organization, who receives the information, is in a position to remedy the problem or alert the affected parties. Usually, the recipients are not aware of the information fully or even partially.

4.15.3 Types

Based on the *destination (recipient),* whistle blowing is classified into types, as:

(*a*) *Internal*: In this case, the information is conveyed to a person within the organization, but beyond the approved channels.

(*b*) *External*: This happens when the information is transmitted outside the organization. The recipient may be a municipal chairman or member of legislature or minister. It becomes severe if the information reaches the press and through them the public. The damage is maximum and sometimes poses difficulty in remedying the situation.

Based on the origin or source (agent), this can be divided into three types, as follows:

(*a*) *Open*: The originator reveals his identity as he conveys the information. This information is reliable and true, but sometimes partially true.

(*b*) *Anonymous*: The identity is concealed. The information may or may not be true. But the agent anticipates perhaps some repression or threat, if identity is revealed.

(*c*) *Partly anonymous (or partly open)*: Such a situation exists when the individual reveals his identity to the journalist, but insists that the name be withheld from others.

4.15.4 When to Justify ?

Under the following situations, the whistle blowing may be justified:

1. When the potential harm existing is identified as serious, or anticipated to occur with a high probability, in the near future.
2. When sufficient data on the harm had been gathered and adequately documented. This condition may not be required if revealing the information would jeopardize the national interests or help the competitors. A request to the appropriate authority for external investigation or permission by a court to release the information may be a solution.
3. The concerns have been reported earlier to the immediate superiors and no satisfactory response was forthcoming from them, within a reasonable time.

4. Regular channels within the organization have been used to transport the information to the highest level of management and the information has reached them. Situations 3 and 4 may not be appropriate, when one's supervisors are the main source of the problem or when urgency demands that regular channels are expected to only add the delay.
5. There is a reasonable hope that the whistle blowing can prevent or remedy the damage existing or anticipated.

Professional societies, unions, and some central laws are there to protect the genuine whistle blowers, but the route is full of adventure still. Laws alone are not sufficient. The engineers and other employees have to act as watch dogs and provide necessary legal assistance to the blowers. The IEEE has taken active roles by assisting the members, backing them when they are to face legal proceedings, helping the engineers discharged unjustly, and honoring the courageous whistle blowers with public recognitions.

To conclude, the whistle blower has to consider (*a*) the personal obligation to family (*b*) right to pursue one's career and (*c*) sometime sacrifices, before this venture.

4.15.5 Before you Blow the Whistle

Here are some of the instructions that should be followed before blowing the whistle:

1. One should familiarize with the rules for appealing within the organization. Normal organizational channels, up to the ombudsman or top ethics committee, should be tried, except when extreme urgency conditions exist.
2. Consult the trusted colleagues for advice and to avoid isolation.
3. Use polite and tactful language. Avoid any personal criticisms that may antagonize and divert the attention towards solving the problems.
4. Keep the supervisors informed of your actions, through informal discussion and formal memorandum.
5. Keep your observations and claims precise and accurate. Prepare formal records of events in support of your claims.
6. Before going outside the organization, consult the ethics committee of your professional society.
7. If necessary consult a lawyer regarding potential litigations.
8. Offering to resign is one of the peaceful and effective methods of blowing your views. Whether you are relieved from the specific project or from the organization, either way your autonomy and self-respect are recognized.

4.16 INTELLECTUAL PROPERTY RIGHTS

Patent, Publish, and Prosper — Dr. Mashelkar, Dir. Genl., CSIR
Future can be best predicted by inventing it — Xerox, USA

4.16.1 Intellectual Property

It is the information and original expression that derives its original value from creative ideas, and is with a commercial value. IP permits people to have fully independent ownership for their innovations

and creativity, like that of own physical property. This encourages the IP owners towards innovation and benefit to the society. It is an asset that can be bought or sold, licensed, and exchanged. It is intangible i.e., it cannot be identified by specific parameters.[11]

The agreements with World Trade Organisation (WTO) and Trade-Related aspects of Intellectual Property System (TRIPS) have been adopted effective from January 2005. Besides the minimum standards set for protection of IP rights, appropriate laws framed by the member countries are expected to reduce distortions and barriers for and promote the international trade. The global IPR system strengthens protection, increases the incentives for innovation, and raises returns on international technology transfer. However, it could raise the costs of acquiring new technology and products, shifting the global terms of trade in favor of technology producers.

4.16.2 Need for Protection of IP

IP plays an essential role to stabilize and develop the economy of a nation. This protection actually stimulates creativity, research, and innovation by ensuring freedom to individuals and organizations to benefit from their creative intellectual investments. The IP serves many purposes, namely

(*a*) it prevents others using it,

(*b*) prevent using it for financial gain,

(*c*) prevent plagiarism

(*d*) fulfill obligation to funding agency. ICICI Bank has advanced loan against IP as security to Shopper's Stoppe, New Delhi, and

(*e*) provides a strategy to generate steady income.

Some of the challenges in the acquisition of IP are:

(*a*) Shortage of manpower in the industry. Educational institutions can play a vital role in providing the same.

(*b*) High cost of patenting and lengthy procedure. This was being considered by the Government and a simpler and faster procedure is expected, and

(*c*) Lack of strong enforcement mechanism.

4.16.3 Types and Norms

The agreements establish norms and conditions for the following instruments of intellectual properties:

1. Patents

Patent is a contract between the individual (inventor) and the society (all others). Patents protect legally the specific products from being manufactured or sold by others, without permission of the patent holder. Patent holder has the legally-protected monopoly power as one's own property. The validity is 20 years from the date filing the application for the patent. It is a territorial right and needs registration. The Patent (Amendment) Act 2002 guarantees such provisions.

Patent is given to a product or a process, provided it is entirely new, involving an inventive method and suitable for industrial application. While applying for a patent, it is essential to submit the documents in detail regarding the problem addressed, its solution, extent of novelty or innovation, typical applications, particulars of the inventor, and the resources utilized. Inventions are patentable and the discoveries are not.

Some of the salient features of the Patent Act 2002 are listed as follows:

1. *Patent outside India*: Applications for Patent outside India, on inventions for defense purposes or related to atomic energy are prohibited. For other patents, an inventor should apply for a patent within India and then seek clearance for filing patents abroad.
2. *Licensing*: The controller of patents grants the license upon verification and on some terms and conditions. The controller shall endeavor to secure that the articles manufactured under the patent shall be available to the public at the lowest price consistent with patentees deriving a reasonable gain from their patent rights.
3. *Negative right*: The grant of patent for an invention does not guarantee the merit or any other commercial value of the invention disclosed. The state which grants the patent does not also guarantee the validity of the patent granted. If other regulations do not permit, even the patent holder can not commence manufacturing. In this context, it is a negative right.
4. *First to file rule*: Indian like many other countries follows the system of first to file or first to register system to determine priority. Accordingly, a patent or invention which is filed or registered first in the patent office will have precedence to the patent or invention, which is filed later in the date, even if it had been invented earlier.
5. *Burden of proof of infringement*: Legal rights of patent can not be enforced automatically. In any suit for infringement of a patent, the patentee must move the court. The court may direct the defendant to prove that the process used by him to obtain the product, identical to the product of the patented process, is different from the patented process.

Types of Patents

(*a*) Utility Patent

The utility patent is granted to anyone who invents or discovers any new and useful process, machine, manufacture or chemical composition of any manner or any new and useful improvement thereof. The utility time is 20 years.

(*b*) Industrial Design Patent

The industrial design patent is an idea or conception regarding features of shape, configuration, pattern, ornamental with lines or colors applied to any article, two or three dimensional, made by any industrial process and is judged by the eye or a product. The Designs Act 2000 excludes from its purview the functioning features of an article and grants protection only to those which have an aesthetic appeal. For example, the design of a tea cup must have a hollow receptacle for holding tea and a handle to hold the cup. These are functional features that can not be registered. But a fancy shape or ornamentation on it would be registerable. A table has a flat surface on which other objects can be placed. This is its functional element. But its shape, color or the way it is supported by legs or otherwise, are all elements of design or artistic elements and they are registerable, if unique and novel. Other examples include the design applied to shoes, T.V., and textiles.

The design patent has a term of 14 years from the date of filing the application. Designs Act 2000 gives further details on this aspect.

2. Copyright

The copyright is a specific and exclusive right, describing rights given to creators for their literary and artistic works. This protects literary material, aesthetic material, music, film, sound recording, broadcasting, software, multimedia, paintings, sculptures, and drawings including maps, diagrams, engravings or photographs. There is no need for registration and no need to seek lawyer's help for settlement. The life of the copyright protection is the life of the inventor or author plus 50 years.

Copyright gives protection to particular expression and not for the idea. Copyright is effective in (*a*) preventing others from copying or reproducing or storing the work, (*b*) publishing and selling the copies, (*c*) performing the work in public, commercially (*d*) to make film (*e*) to make translation of the work, and (*f*) to make any adaptation of the work. Copying the idea is called 'plagiarism' and it is dealt with separately.

Can software be protected through copyright? Indian copyright Act amended in 1984 included the rights of in a computer program as literary work. Many countries protect software as a copyright. Some holds the view that copyright is not the right type of protection for software. They held that the patents and trade secrets are more appropriate forms of protecting software. While trade secret is the most conventional form of protection of software, in the recent years, both patents and copyrights are adopted to protect software.[11]

Copyright (Amendment) Act 1999, India ensures fair dealing of broadcasting through the internet. The concerns of Book industry, Music Industry, Film and Television Industry, Computer Industry and Database Industry are sufficiently met by this updated Act.

3. Trademark

Trademark is a wide identity of specific good and services, permitting differences to be made among different trades. It is a territorial right, which needs registration. Registration is valid initially for 10 years, and renewable. The trademark or service mark may be registered in the form of a device, a heading, a label, a ticket, a letter, a word or words, a numeral or any combination of these, logos, designs, sounds, and symbols. Trademark should not be mistaken for a design, e.g., the shape of a bottle in which a product is marketed, can not be registered as a trademark. Trademarks Act 1999 made in compliance with TRIPS agreement, provides further details.[11]

There are three functions of trademark:

1. Just as we are identified by our names, good are identified by their trademarks. For example, the customer goes to the shop and asks for Lux soap. The word 'Lux' is a trade mark. In other words it shows the origin or source of the goods.
2. The trademark carries with it an inherent indication or impression on the quality of goods, which indirectly demonstrates that it receives the customer's satisfaction.
3. The trademark serves as silent sales promoter. Without a trademark, there can be no advertisement. In other words, it serves as a medium for advertising the goods.

The marks should be distinctive i.e., it should be able to distinguish from one good to the other. The terms used for trademarks are usually generic, descriptive, and suggestive. Some of the term which are not distinctly distinguishing the goods or services from others, are called *generic term* and are eligible for protection under trademarks. The descriptive term should clearly indicate or convey the specific purpose, function, physical characteristic and the end use of the product. Relatively, the suggestive

marks do not describe the goods at first sight, but with an element of imagination or perception the nature of the goods can be understood. Thus, the suggestive marks are distinctive and are protected as trademarks. Arbitrary marks and fanciful marks are distinctive and hence accepted for registration.

Besides this, there is also a certification mark by the Bureau of Indian Standards (BIS or ISI) which guarantees that the holder's product bearing the mark has met certain standards or requirements. This adds considerably to the market value and to a great value in the export trade.

4. Trade Secret

A trade secret is the information which is kept confidential as a secret. This information is not accessed by the any other (competitor) than the owner and this gives a commercial advantage over the competitors. The trade secrets are not registered but only kept confidential. These are given limited legal protection, against abuse by the employee or contractor, by keeping confidentiality and trust.

The trade secrets may be formulae, or methods, or programs, or processes or test results or data collected, analyzed, and synthesized. These are related to designs, technical processes, plant facilities, list of suppliers or customers etc. This information should not be disclosed or used by any other person.