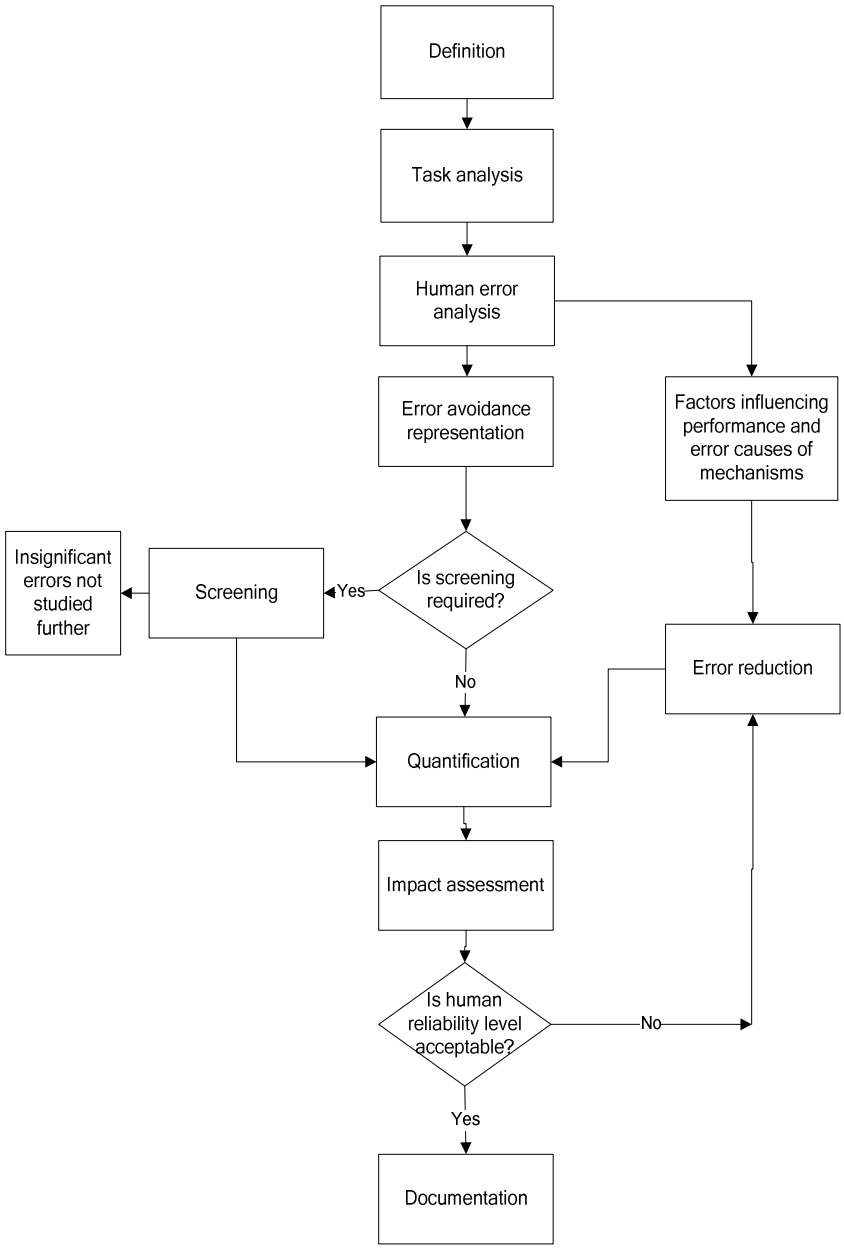

Figure B.7 – Example of human reliability assessment

B.21 Bow tie analysis

B.21.1 Overview

Bow tie analysis is a simple diagrammatic way of describing and analysing the pathways of a risk from causes to consequences. It can be considered to be a combination of the thinking of a fault tree analysing the cause of an event (represented by the knot of a bow tie) and an event tree analysing the consequences. However the focus of the bow tie is on the barriers between the causes and the risk, and the risk and consequences. Bow tie diagrams can be constructed starting from fault and event trees, but are more often drawn directly from a brainstorming session.

B.21.2 Use

Bow tie analysis is used to display a risk showing a range of possible causes and consequences. It is used when the situation does not warrant the complexity of a full fault tree analysis or when the focus is more on ensuring that there is a barrier or control for each failure pathway. It is useful where there are clear independent pathways leading to failure.

Bow tie analysis is often easier to understand than fault and event trees, and hence can be a useful communication tool where analysis is achieved using more complex techniques.

B.21.3 Input

An understanding is required of information on the causes and consequences of a risk and the barriers and controls which may prevent, mitigate or stimulate it.

B.21.4 Process

The bow tie is drawn as follows:

a) A particular risk is identified for analysis and represented as the central knot of a bow tie.

b) Causes of the event are listed considering sources of risk (or hazards in a safety context).

c) The mechanism by which the source of risk leads to the critical event is identified.

d) Lines are drawn between each cause and the event forming the left-hand side of the bow tie. Factors which might lead to escalation can be identified and included in the diagram.

e) Barriers which should prevent each cause leading to the unwanted consequences can be shown as vertical bars across the line. Where there were factors which might cause escalation, barriers to escalation can also be represented. The approach can be used for positive consequences where the bars reflect ‘controls’ that stimulate the generation of the event.

f) On the right-hand side of the bow tie different potential consequences of the risk are identified and lines drawn to radiate out from the risk event to each potential consequence.

g) Barriers to the consequence are depicted as bars across the radial lines. The approach can be used for positive consequences where the bars reflect ‘controls’ that support the generation of consequences.

h) Management functions which support controls (such as training and inspection) can be shown under the bow tie and linked to the respective control.

Some level of quantification of a bow tie diagram may be possible where pathways are independent, the probability of a particular consequence or outcome is known and a figure can be estimated for the effectiveness of a control. However, in many situations, pathways and barriers are not independent and controls may be procedural and hence the effectiveness unclear. Quantification is often more appropriately carried out using FTA and ETA.

B.21.5 Output

The output is a simple diagram showing main risk pathways and the barriers in place to prevent or mitigate the undesired consequences or stimulate and promote desired consequences.

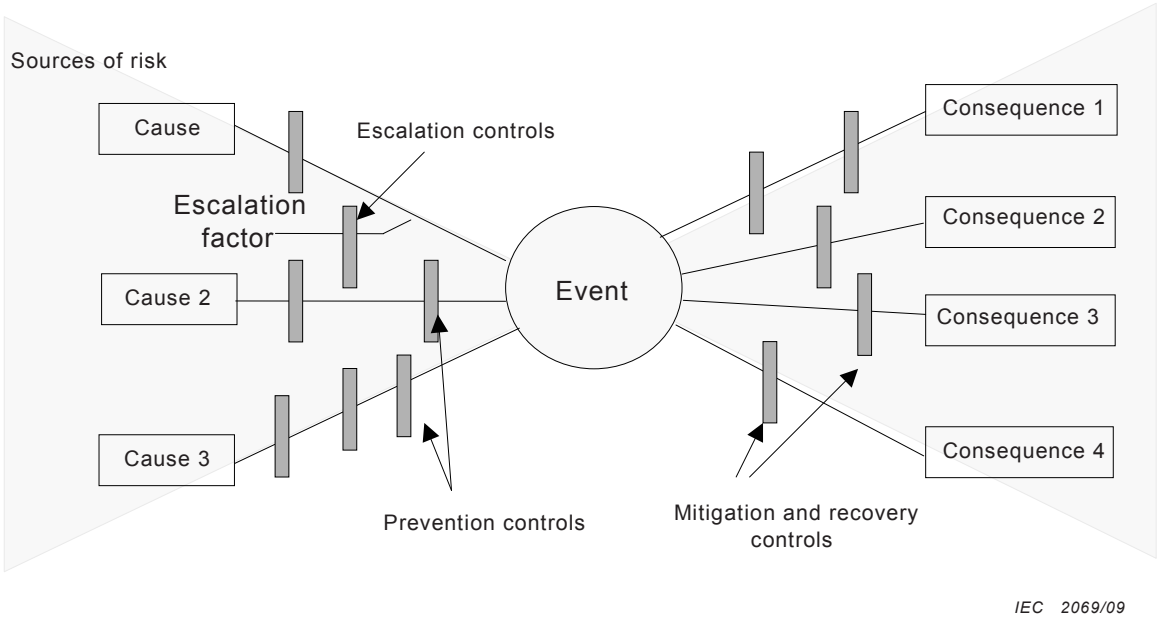

Figure B.8 – Example bow tie diagram for unwanted consequences

B.21.6 Strengths and limitations

Strengths of bow tie analysis:

- it is simple to understand and gives a clear pictorial representation of the problem;
- it focuses attention on controls which are supposed to be in place for both prevention and mitigation and their effectiveness;
- it can be used for desirable consequences;
- it does not need a high level of expertise to use.

Limitations include:

- it cannot depict where multiple causes occur simultaneously to cause the consequences (i.e. where there are AND gates in a fault tree depicting the left-hand side of the bow);
- it may over-simplify complex situations, particularly where quantification is attempted.

B.22 Reliability centred maintenance

B.22.1 Overview

Reliability centred maintenance (RCM) is a method to identify the policies that should be implemented to manage failures so as to efficiently and effectively achieve the required safety, availability and economy of operation for all types of equipment.

RCM is now a proven and accepted methodology used in a wide range of industries.

RCM provides a decision process to identify applicable and effective preventive maintenance requirements for equipment in accordance with the safety, operational and economic consequences of identifiable failures, and the degradation mechanism responsible for those failures. The end result of working through the process is a judgment as to the necessity of performing a maintenance task or other action such as operational changes. Details regarding the use and application of RCM are provided in IEC 60300-3-11.