**Slide 1:**

I’m going to talk about some frameworks to identify hazard scenario’s and how you can use these to analyse consequences and probabilities. Then you can identify risk scenarios and analyses sensitivities.

The most important thing is that you let your stakeholders know what you take into account and what not.

**Slide 2:**

If we look at identifying hazards you can ask yourself three questions.

What might go wrong? This can be everything.

How can it happen?

And what controls exist? So what are the rules and regulations but also what are the boundaries etc.

It is crucial that before you answer these questions you have a derailed understanding of the system and you only take the identified hazards into account in you further analysing process.

This is important because you can only define the right hazard if you truly know the system you are talking about.

One of the methods we can use for hazard identification is the Fault tree analyse

**Slide 3:**

In a fault tree analyse you give structure to the events that eventually lead to the accident. You can use the fault tree in an retrospective way, accident analyse and in a prospective way, process analyse. It also allows you to give the probability of failure in the accident.

In the next slide I will explain how to make the fault tree.

**Slide 4:**

You start with the top event. So the hazard you identified. Then you can work down. The end point is the basis of the failure. It it a little fault what lead to the big event.

Theoretically this tree can be on and on because you always can think of a smaller event that leads to the bigger event.

As I already said you can implement probability so you can see which events is most likely to happen and so you know which one is the most important to take into account. If you use probabilities you need to make sure that these are clear and agreed on with your stakeholders. They have the same level of detail and they correspond with the type of consequence.

You have two options in the tree, you can uses and gates if both accidents need to happen for the bigger event to happen. And you can use the or gates. Then just one of the events need to happen for the bigger event to happen.

**Slide 5:**

A second method you can use is the bowtie model. In this model you only have or gates. And you can’t use probabilities.

The left side are the causes, they lead up to the event. You can than see that a particular hazard can go out of control but you can still do something in the earlier stages to prevent this. This isn’t always bad if you just anticipate on it. It’s just unwanted.

The right side is the consequences. These consequences can be divided in three categories.

The first is loss of life. This means that the consequence makes a person less happy. Like if your car broke down and everything is far away you can’t travel to this so that is bad for your happiness.

The second is injury. If you use a chair and something broke so you collapse with your chair you can get injured.

The last is economical loss. This is easy to understand, the consequences are making your profit less than if the accident didn’t occur.

You can see that the bowtie uses the fault tree. You first take the hazard, than you think what are the potential risks. What can I do to control the risks? And there you see the fault tree. And last you think of What can I do if it goes wrong.

**Slide 6:**

You need to do a sensitivity analysis because the risk analysis is associated with uncertainty/incompleteness.

The reason for this are: inherent or natural variability, modelling uncertainty. And statistical uncertainty. You make assumptions in your analyse. You don’t know all the relationships precisely. And not all your data is available.

The reason you do this analysis is that you know what the effect is of changes in your chosen input variables, relations and data. Most systems are dynamic so a lot of things can change over time. You need to take this into account. Also you made assumptions and they can be wrong. You need to take this into account.

Also here you need to make sure that all the stakeholders agree on the chosen method. Because they need to have trust in your analysis.

**Slide 7:**

When you establish risks you can put them in a risk assessment matrix. You are going to put all the found hazards in categories so you get an overview and it is good for your stakeholders to see where the big problems are. So you categorise them in frequency of occurrence and how big the hazard is when it occurs.

If you did that you can colour hazards. Mostly used is the ALARA-principle. As Low As Reasonable Achievable.

Red is intolerable risk, this need to be excluded. Yellow is undesirable. This is tolerable if the cost for improvement are way too high. Or further risk reduction is impracticable. Light green is tolerable if the cost of risk reduction would exceed the improvement gained. Last is darker green and this is negligible risk.

**Slide 8:**

The last step to take is the treatment of risk. You know no what the risk is and how important it is to change the situation. You can do this in four categories. If we look at the crocodile you see that you can avoid risk, you can get rid of the crocodile. You can reduce the risk, if you move to somewhere else the crocodile can’t bother you anymore. You can transfer the risk, so you can put the crocodile into a cage and then you don’t be bothered by it anymore. Last you can accept the risk and just protect yourself against the risk.

**Slide 9:**

This measurement can be implemented as barriers. You can use the hazard Barrier target model (HBT). Hazards can be physical or procedural or a combination of course. The barriers keeping the flows from reaching the target. But the implementation cant fully eliminate the hazard!

Barriers can be shown in the bowtie model, blocking pathways or scenario’s. unfortunately there will always be pathways that still be open. They are exposed when an accident happened or something goes wrong. You see here were the different measurements can be implemented in the bowtie.

Last I want to say that risk analysis never stops, it will always continue because things change, data, variables, knowledge or external factors. We need to learn from these changes and take them into account.