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Checklists for surveying and assessing industrial plant handling materials and substances, which are hazardous to water

Manual of actions

For our Environment

Umwelt Bundesamt

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Checklists for surveying and assessing industrial plant handling materials and substances, which are hazardous to water

Manual of actions

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INTRODUCTION

In practice industrial accidents can have extensive transboundary effects in waters - in particular leading to restriction in their use as drinking or industrial water as well as damages to the ecosystem. Therefore it is necessary to apply a transboundary concept, applicable in all European countries to assess industrial plants with regard to their safety.

FIG. 1: Sandoz, 3 November, 1986

On the basis of the recommendations of ICPR/ICPE a checklist concept was developed, which enables to undertake an excellent examination of plants. Existing recommendations were converted into a question and answer profile with suggestions on the kind of measures to be taken integrated. This concept was checked against international regulations and technical proposals for solutions and was found to be complete. It therefore reflects the European standard.

In order to establish this concept as a practical testing method there is a need for an introduction of it to make the subject matter understandable.

In order to be able to work with the checklists, certain things must be considered.

Step 1– Dividing the factory into smaller units

It is surely logical that an entire factory cannot be examined at once. A factory consists of many smaller units and components of different characters. There are loading and offloading units, filling units, storage units, manufacturing -, treatment- and auxiliary units. Since as a matter of rule the various units are interconnected by pipes the partitioning must be done in a sensible way.

In order to achieve a meaningful division of the factory there is a need to define what a plant is.

Plants are independent and stationary units or stationary process units, in which substances harmful to water are handled. Plants contain all other components like containers, pipeline and space necessary for normal operation.

The division of respective plant into separate units can then be effected after the definition of a plant is clarified. The division of a plant is usually done by its owners according to the productional purposes of the company. Operationally interconnected functional units make up a plant unit.

The following principles are to be considered when dividing a factory into smaller units:

- The plant must be divided according to the function of each unit namely according to S (Storage), F (Filling), T (Transhipment), MTU (Manufacturing, Treatment and Utility).
- The operational goal is a decisive factor on how the plant is divided. An important criterion to achieve the engineering goal of the process is the material flow.

- Separate containers, even if they are located close to one another, belong to separate plants if they are attached to different filling systems or assigned to different MTU-Units. This applies also to a group of containers with joint aeration and venting pipes as long as there is no danger of a build-up of overpressure or under pressure and no liquid can enter the pipes during all phases of operation. The fact that containers are installed in the same secondary containment does not mean they belong to the same plant.
- An MTU-plant that produces, treats or acts as an auxiliary unit is still an MTU plant even when waste water is released. A plant treating waste or liquid waste, is an MTU plant as long as it handles substances that are hazardous to water even if waste water is released.
- A plant that processes wastes, including liquid waste, is an MTU plant, as long as it handles substances hazardous to water even when waste water is discharged.
- A plant, which treats waste water only for the purpose of releasing it into the sewage system is a waste water treatment plant and will not be examined here.

Example of a plant:

1. A storage unit that consists of tanks also includes safety devices, such as: overfill device, leakage indicator, pipes with their fittings, and secondary containment
2. A loading and offloading unit consists of pumps, pipes with fittings, containment areas and the areas used for loading and offloading.

Examples of plants used in a stationary manner are:

- Vehicles which are no longer used as cars but as containers for handling substances hazardous to water,
- Barrels, because they can not move on their own.

Examples of mobile plants and plants used in a stationary manner that are operated only temporarily and at changing locations:

- mobile filling stations for construction sites,
- vehicles for transportation,
- Emergency heaters for reconstruction of buildings.

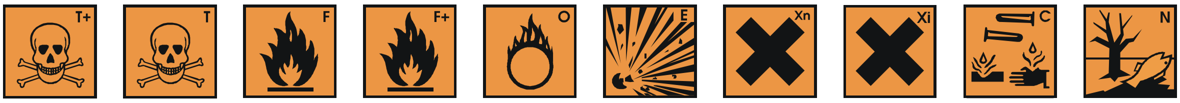
These are not to be examined here but should however meet certain requirements and general safety principles (mobile containment, such as leakage basins and oil binding agents, constant supervision during filling and emptying).

Step 2– Determination of substances which are hazardous to water

After defining the plant, the next step is to examine the level of threat posed by the plant.

What are the substances that are hazardous to water: Several dangerous characteristics play a role e.g. the danger to humans, ecological danger, algae toxicity, bacterial toxicity, their tendency to accumulate in organisms, degradability etc. In order to be able to summarise these characteristics, a commission was founded in Germany to evaluate every substance on the basis of the aforementioned criteria. Three water hazard classes were introduced (WHC 1 to WHC 3).

The differences between the individual WHCs classes is in the range of factors 10 -100. (1 ton of substance classified as WHC 3 is at least 10 times more dangerous than 1 ton of WHC 2 substance and at least 100 times more dangerous than 1 ton of WHC 1substance). In Germany several thousand substances have been classified. This database can be accessed on the Internet and is available both in German and English.



(http://www. webrigoletto.uba.de/rigoletto/public/welcome.do)

All substances hazardous to water can now be registered in the following checklist. After comparison of substances it is possible to calculate the Water Risk Index (WRI), which is an expression of potential danger. The detailed instruction is available in the annex of the Checklist 1 **Checklist: 01.pdf „Substances“**

If after working with this checklist no substance hazardous to water has been included, the survey can be terminated.

Step 3– Requirements for certain plants

1.1 Are there tanks, reactors and other containers in the plant?

Checklist: 13.pdf „Storage“

Checklist: 14.pdf „Equipment of tanks“

Checklist :18.pdf „Construction and equipment of plants »

1.1.1 Overfill safety devices

According to ICPR/ICPE recommendations, If there are tanks, reactors or other containers in the plant, they can only be filled with substances hazardous to water if they are equipped with overfill safety devices. Overfilling of containers is frequently the cause of accidents. Overfill safety devices prevent these accidents effectively and are therefore extremely important safety measures for accident prevention.

Checklist: 02.pdf „Overfill safety devices“

1.1.2 Pipelines

Generally these tanks are connected with pipelines either within the plant in question or to other plants in the factory. These pipelines should be able to withstand all possible chemical and physical stress affecting them. An exact summary is available in the following checklist.

The pipelines examined here are either fixed or flexible pipelines for transporting substances hazardous to water.

Pipelines can be independent piping units or part of units for storing, filling, loading and offloading, manufacturing, treating and utilising of substances hazardous to water. This applies in particular to pipelines, which connect plants for storing, filling, loading and offloading, manufacturing, treating and utilising of substances hazardous to water or for pipelines which are temporarily used for filling and emptying units, that are used for storing, manufacturing, treating and utilising of substances hazardous to water and which are emptied after the operation (filling and emptying pipe). Pipelines where the position can be altered due to operating conditions, in particular hose connections and pipelines with joint connection are considered flexible. Venting pipes of tanks are not liquid-handling pipelines and as such do not count as pipelines in our understanding. Pipelines can be installed above or under the ground. Pipelines that are partially or completely installed underground are considered to be underground pipelines. Any fittings and pumps are considered parts of a pipeline. **Checklist: 03.pdf „Pipeline safety“**

1.1.3 Joint storage

Hazardous substances and compounds (in accordance with EEC guideline 67/548/EWG) must be stored according to their characteristics. If these substances are to be stored:

a) in a room of a building;
b) a free space outdoors without stable and fireproof wall or sufficient safety gap (in the order of 8 - 10 m);
c) in a joint containment and/or a partitioned tank, then additional requirements must be complied with. These are described in summary in the checklist "Joint storage". **Checklist: 04.pdf „Joint storage“**

1.1.4 Containment capacity, Fire prevention strategy

As there is the possibility that the wall of a single shell tanks could fail, it is necessary to create a secondary containment, which would serve as a second barrier. The secondary containment must be sufficiently dimensioned.

What is meant by sufficiently dimensioned?

To be sufficiently dimensioned means: the containment capacity of the secondary containment must be big enough so that no other measures would have to be taken into consideration, to contain the amount of liquid substances that can be spilled in case of an accident. The volume of the largest separate/independent section at the plant can be used as a basis for the calculation of the containment capacity. Note: the volume of a secondary containment must correspond to the volume of the plant set up in it. If several plants are in a secondary containment, the volume of the largest plant determines the containment capacity. However, at least 10 % of the entire volume of all plants set up in the secondary containment must be contained.

If counter measures are possible, it must be examined whether these are realistic and practicable. These counter measures should be mentioned in the checklist.

For secondary containments that are not roofed, additional containment capacity of about 50 l/m² for rainwater should be added. If there are no other surfaces allowing additional water into the secondary containment, a simple freeboard of about 5 cm can be installed.

The aspect of the evaluation of the containment capacity will be looked into in the Checklist 08 „Fire prevention strategy". Even if no inflammable substances are present the corresponding questions 1.1 and 1.2 must be answered.

When inflammable liquids are stored or handled, containment for fire-fighting water must be provided when the stored liquid exceeds a certain amount. For substances of class WHC 1 > 100 t applies, class WHC 2 > 10 t and class WHC 3 > 1 t for each tank farm and/or tank farm section. In case of fire outbreak substances hazardous to water could, on one hand, be released and on the other hand fire-fighting agents are brought in to extinguish the fire. That means the capacity of the containment to retain the released liquid can be calculated as given above. The volume of the fire-fighting agents used to extinguish the fire will have to be added. When heavy foam is used as fire extinguishing agents, it is enough to increase the height of the containment by 30 cm. **Checklist: 08.pdf „Fire prevention strategy“**

1.1.5 Sealing system

Sealing systems are tight and resistant constructions of secondary containments (or similar) which could come in contact with hazardous substances resulting from leakages during accidental discharge. Sealing systems are responsible prevent these hazardous substances from penetrating the secondary containments.
A concrete surface or a foil covering the concrete surface can be used for example as a sealing system.
Checklist: 05.pdf „sealing system“

1.1.6 Split-flow wastewater

Waste water partial flows are continuous and intermittent industrial waste water (e.g. waste water from production plants, auxiliary facilities and laboratories) as well as cooling and rain water. Waste water should be as much as possible avoided by using adequate technology (by for example, air cooling, vacuum systems without water and etc.), by using environmentally friendly production techniques and by means of alternative process management when drawing up concepts for a waste water system. Open water-cooling systems (as opposed to closed systems where no water is added or discharged) should be avoided. **Checklist: 06.pdf „Split-flow waste water“**

1.2 Small drums storage

Small drums storages are checked like the plants described under point 3.1, but the point 3.1.1 on overfill safety devices and 3.1.2 on pipelines can be left out. **Checklist: 13.pdf „Storage“**

1.2.1 Containment capacity

In this case the containment capacity for water hazardous substances can be estimated with a different method.

The size can be determined as follows:

Total volume of the plant in m³	Containment capacity
≤ 100	10% of total volume of the plant, at least the volume of the largest container
> 100 - ≤ 1000	3% of volume of the plant, at least 10 m³
> 1000	2% of total volume of the plant, at least 30 m³

Example: Storage of drums in shelves

1.3 Storage of solid substances

The storage of solid substances hazardous to water has a relatively low risk.

Checklist: 13.pdf „Storage“

Solid substances hazardous to water must be stored:

- on a floor that is impermeable for the substances under all operating and climatic conditions and
- the substances must be

a) In tight containers or packages that are protected against damage and climatic influences and also resistant to the substances.

b) Stored, filled, loaded or offloaded in rooms. Closed rooms are treated like surfaces which are protected from climatic influences, access of water and other liquids in such a way that the substances cannot spill out.

If solid substances are stored loosely or in bags in a storage site that is equipped with only a roof, it should be covered from all sides such way that the substances remain in the area covered by the roof.
Silos are considered to be closed storage.

For the evaluation of the floor see - **Checklist: 05.pdf „Sealing system“**

“Protection against water and other liquids in outdoor storage facilities” means the substances are protected from rain and can not be washed away. To achieve this, the storage must be adequately roofed. The roofing is adequate, if the roof exceeds the sealed area by 2/3 of the headroom. Also rain water run-off must be kept away by construction of slopes or with a concrete barrier.

If the solid substances can be washed away by rain water, the run-off must be discharged to a wastewater treating plant. **Checklist: 06.pdf „Split-flow wastewater“**

1.4 Transshipment of substances hazardous to water

The loading and offloading can be seen as a link between transportation and storage. The recommendations refer to the technical and organizational measures necessary to prevent hazardous substances from polluting surface water on the site where these substances are loaded and offloaded. The sector for “Transshipment” refers to the stationary area where the loading and offloading from or onto ships, lorries and railway is done (e.g. stores and storage hall).

The checklist 07 „Transshipment of substances hazardous to water" was developed in order to be able to check this complex area.

Checklist: 07.pdf „Transhipment of substances hazardous to water“

A questionnaire is provided to support the preparation of the transhipment process for ships an to help avoiding uncertainties. This questionnaire is directed at the captain of the ship and the person responsible in the port of loading and offloading.

Checklist: 07-1.pdf „Transhipment of substances hazardous to water“

1.4.1 Sealing systems

Sealing systems are tight and resistant constructions of secondary containment and collecting surfaces which are likely to come in contact with water-hazardous substances resulting from leakages through

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accidental discharge. Sealing systems are meant to prevent these water-hazardous substances from penetrating the secondary containment or collecting surface.
A concrete surface or a foil covering the concrete surface can be used as a sealing system.
This problem was briefly touched in point Nr. 1 of the check list 07 „Transhipment of substances hazardous to water" This topic is however treated in detail in the check list 05 „Sealing systems".
Checklist: 05.pdf „Sealing systems“

1.4.2 Pipelines

If substances hazardous to water are pumped through a pipeline, then point Nr. 2 of checklist 07 will have to be considered. This problem is however treated in detail in the Checklist 03 "Pipeline safety". The pipelines include also all fittings and pumps (see also 3.1.2)
Checklist: 03.pdf „Pipeline safety“

1.4.3 Containment capacity

To be able to complete point Nr. 4 in the checklist 07, the definition for sufficiently sized secondary containment must be straightforward and clear.
For this, a small calculation is necessary:
The Containment capacity (R) can be calculated as follows:

$$R = \dot{V} \cdot t_A$$

R Containment volume in m^3
$\dot{V}$ Flow rate in m^3/h
t_A Time until adequate safety measures will be effective in h

In some cases, damage to the pipe can cause liquid to be released on both ends of the pipe. If this is a possibility, it must be considered.

1.4.3.1 Calculation of flow rate

The flow-rate is considered to be equal to the maximum pump capacity of the pump used.
The flow-rate can be calculated as free drain as follows:

$$\dot{V} = 3600 \cdot A\sqrt{2gh}$$

$\dot{V}$ Volumetric flow-rate m^3/h
A cross section of pipe
g 9,81 m/s^2 acceleration of gravity
h maximal height in meters

1.4.3.2 Determination of the time until adequate safety measures becomes effective

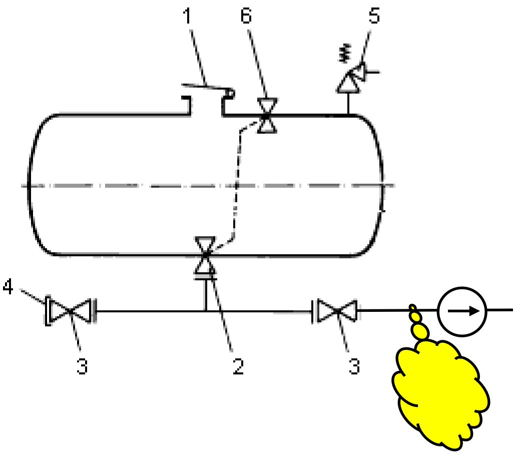
$$t_A = t_T + t_R$$

t_T dead time – the time a reacting systems needs, to recognise incoming signals as relevant
t_R reaction time – that is the time a reacting systems needs, to arrive at a set point after recognising incoming signals.

If the time can not be defined exactly, a time equal to will be assumed.

$$t_A = 5\ min$$

Example: A tanker is being emptied. The hose got damaged near the pump. The hose is 100 mm in Diameter. The level is about 3 m above the point of damage.



assuming a time t_A of 5 min, the containment volume should be:

$$\dot{V} = 3600 \cdot \frac{\pi}{4}(0{,}1)^2\sqrt{2 \cdot 9{,}81 \cdot 3}$$

$$\dot{V} = 216{,}92 m^3 / h$$

R = ca. 18 m³

1.4.4 Fire prevention strategy

When inflammable liquids are stored or handled, containment structures for fire fighting water must be provided. In case of fire, substances hazardous to water can be released and fire-fighting agents are applied to extinguish the fire. That means the capacity of the containment to retain the released liquid can be calculated as given above. The volume of the fire fighting agents used to extinguish the fire will have to be added to it. When heavy foam is used as fire extinguishing agents, it is sufficient to increase the height of the containment by 30 cm.

Checklist: 08.pdf „Fire prevention strategy“.

1.4.5 Split-flow wastewater

Split-flow wastewaters are continuous and intermittent industrial waste water (e.g. waste water from production plants, auxiliary facilities and laboratories) as well as cooling and rain water. Waste water should be as much as possible avoided by using adequate technology (by for example, air cooling, vacuum systems without water and etc.), by using environmentally friendly production techniques and by means of alternative process management when drawing up concepts for a waste water system. Open water-cooling systems (as opposed to closed systems where no water is added or discharged) should be avoided **Checklist: 06.pdf „Split-flow waste water“.**

1.5 Checks which are valid for all types of plants

1.5.1 Industrial plants in areas with risk of flooding

These requirements apply to plants, sections of a plant (including pipelines) and safety devices which can be affected in case of flooding. It does not matter whether the flooding is due to high tide, backwater from rivers or drainage systems, rise in the level of groundwater due to severe flooding or contained fire-fighting water.

In checklist 11 „Industrial plants in areas with risk of flooding“, an introductory question examines the relevance of this list to the plant. If the opinion is that all these four dangers, high tide, static water, rise in groundwater level and contained fire fighting water do not pose any risk, then this checklist is not relevant. This will serve as a proof that the examiner has done preliminary work on the topic. If this topic happens to be relevant then the safety measures taken must be examined. **Checklist: 11.pdf „Industrial plant in area with risk of flooding“.**

1.5.2 Plant monitoring

The monitoring of plants should ensure that accidental release of substances hazardous to water is avoided. During the process of monitoring, one needs to differentiate between in-plant monitoring by plant operators and official monitoring by the authorities. The main responsibility for monitoring the plant lies with the plant operators. The monitoring by the authorities is a sort of control of the responsibility by the plant operator to adequately monitor their plant.

In-plant monitoring measures should give priority to those places, where substances hazardous to water must be controlled and prevented from release. Monitoring should enable a timely recognition of the situation and the initiation of immediate remedial measures. **Checklist: 09.pdf „Plant monitoring“**

Step 4– Hazard control planning

4.1. Internal alarm - and Hazard control planning

Internal alarm and hazard control planning and fundamental safety obligations by operators of accident-relevant plant. It describes the type and procedure of designated organizational and technical measures to be taken after recognising a danger which can lead to a dangerous situation or a danger which already created a dangerous situation. These measures are, apart from other technical and organizational safety precautions, a fundamental basis for preventing accidental release of substances hazardous to water as well as reducing the effects of possible accidental release into the waters.

Checklist: 10.pdf „Internal alarm- and hazard protection planning“

4.2. Structure of safety reports

In case of accidental release in factories near reservoirs, the supply of drinkable water of a whole region could be harmed and contaminate biotopes extensively.

In order to assess the danger of major accidents and determine adequate plant-related measures for their prevention or limitation and to make this a priority, effective methods to ensure the safety of plants demand a systematic and comprehensive analysis.

The approach for conducting such comprehensive surveys is to apply the Severso II Directives of the EU[1] and to fully exhaust all appropriate rules concerning plant safety for the protection of water, as specified within the laws and regulations of the affected states.

Preparing a safety report is one of the major requirements that must be fulfilled by operators of dangerous plants on which these directives are to be applied.

The safety report provides the plant operator with an overview of the whole plant and the respective plants in terms of safety. Already during the preparation of the report, the enterprise can recognize weak points in the safety system and obtains hints on how to improve production safety. This process helps the senior management to understand that stability and operability of the plant has a direct influence on the profitability of the enterprise.

The authorities are able to use the information contained in the safety report as a basis for issuing out precise short-, medium- and long-term measures and precautions for preventing major accidents as well as stipulating, in collaboration with the enterprises, measures to be taken to limit the effects of major accidents. **Checklist: 12.pdf „Basic structure of safety reports concerning hazards to water“.**

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[1] *Common point of view (EC) of the council released on the 19 March 1996 (9743/6/95 REV 6) regarding the decreed Directives released by the council for the control of danger from major accidents involving hazardous substances.*

Step 5– quantitative expression of the safety level

The actual level of security can only be established on the basis of detailed checking and evaluation of appropriate facilities. To do this, a very suitable method is the already developed Checklist. With this method a varied set of facilities can be checked and evaluated according to international recommendations in a simple and structured manner.
This method is used at the entire industrial site.

5.1. Evaluation of the Modified Water Risk Index (WRI)

The assessment of actual risk must consider the environment of the site. It is highly relevant if facilities are threatened by natural disasters or if an accident would interrupt the drinking water supply in the region. This would mean that the surroundings would have to be assessed keeping these factors in mind. Of course a precise delineation is required, e.g. as of which level a earthquake can be considered dangerous and at which level flooding is considered a threat.
It is important to understand that the true risk potential should be considered only in connection with risks for the environment. Therefore, we introduce a modified WRI (Water Risk Index).

$$\mathbf{MWRI = WRIs + M1 + M2 + M3}$$

MWRI	Modified water risk index for water
WRIs	Water risk index in the area
M1	Danger of earthquake
M2	Danger of flood
M3	Sensitive area

5.1.1. Earthquake

Earthquake hazard should be considered if earthquake with intensity 4 on the Richter scale can occur in the region. Level 4 on the Richter scale means:
Many people can feel it, the pendulum swings clearly, plates and glasses are rattling, swings shutter, parked vehicle can slightly shake; a damage is minor.
If this is the case, a modification point is set up.

M1 = 0,1 M1 = 0 (no danger of earthquake).

5.1.2. Flood

Flood is a phenomenon that occurs when rivers, lakes and seas over flow their banks or shores. It is necessary to consider the last 100 years to check if such an event has occurred.
If the answer is “yes”, a modification point should be determined.

M2 = 0,1 M2 = 0 (no any danger of flood).

5.1.3. Sensitive areas

Sensitive areas are those areas where drinking water is sourced for a large amount of population. This category also includes nature conservation areas. If the hazardous substances are released to water, there is a greater impact on the population and the environment. For this reason, in these cases a point of modification is determined.

M3 = 0,1 **M3 = 0 (non-sensitive area)**

5.2. Establishing the potential danger in every detail of construction

For the each part of the plant, the potential danger must be identified using the Water Risk Index, as described in Checklist 1.

5.3. Determination of the necessary Checklists

For the each part of the plant, the relevant checklists are selected. Since the method of checklists list is based on a modular form, the checklists that are used can vary.

5.4. Determination of the average risk category of each checklist

Once the checklists are determined, on the basis of the data the plant parts can be tested and evaluated. Each checklist is to be processed and checked individually to which extent the recommendations of International River Commissions have been implemented.
It is also necessary to check whether the separate sub-points of these Recommendations were followed. Risk categories are introduced for this purpose:

The sub-point of the recommendation is implemented (Normal risk):	**RC = 1**
The sub-point of the recommendation is partially implemented (Medium risk):	**RC = e.g. 5**
The sub-point of the recommendation is not implemented (High risk):	**RC = e.g. 10**

For the each sub-recommendation commonly three parameters given from which a risk category can be selected according to the sub-point. If the sub-point is not significant, then it will not be evaluated further (for example, there is a recommendation for underground pipelines, and the plant only contains above ground pipelines. In this case, the sub-point will not be assessed).
At the end of each checklist the average risk category of the each sub-point is calculated.

$$ARC_n = \frac{\sum_m RC_{SP}}{m}$$

ARC_n	Average risk of the Checklist n;
M	Number of evaluated sub-points of recommendations*;*
SP	Sub-point (sub-point of recommendations);
RC	Risk category.

5.5. Determination of the average risk category of the each part of the facility

After the average risk category was established for the each checklist, the average risk for each of the facilities can be defined

$$ARP_i = \frac{\sum_{CL} ARC_n}{CL}$$

ARP_i	Average risk of the plant i
ARC_n	Average risk of the Checklist n
CL	Number of evaluated Checklists

5.6. Determination of actual risk for every part of the facility

The actual risk of the every part of the plant can be set up as a decimal logarithm of multiplying the equivalent EQ3 of plant parts and average risk of plant parts

$$RRP_i = \lg(10^{WRI_i} \bullet ARP_i) = \lg(EQ3_i \bullet ARP_i)$$

RRP_i	Real risk of the plant i;
$WRI\ i$	Water risk index for plant parts i;
$EQ3i$	Equivalent EQ3;
$ARPi$	Average risk of plant i.

Following evaluation was set up:

$(RRP_i - WRI_i) \leq 0,4$	**Very good level of security. However, this classification does not mean that there should be no action to improve the situation.**
$0,4 < (RRP_i - WRI_i) \leq 0,8$	**Important safety installations are missing or insufficient. Actions to improve safety must be taken.**
$(RRP_i - WRI_i) > 0,8$	**The level of security regarding the protection of water is very low. IT is necessary to improve the situation and to repeat the evaluation afterwards.**

5.7. Determination of the average risk category of a site

To determine the actual risk of a site, the plant parts should be summed up. For this, the average-risk category of the facility is required. The average value is estimated using the WRI (risk index for water) for plant parts.

$$ARSite = \frac{\sum_k \left(10^{WRI_i} \bullet ARP_i\right)}{\sum_k 10^{WRI_i}} = \frac{\sum_k (EQ3_i \bullet ARP_i)}{\sum_k EQ3_i}$$

$ARSite$	Average risk of industrial location;
ARP_i	Average risk of the plant i;
RRP_i	Real risk of the plant i;
$EQ3_i$	Equivalent EQ3;
WRI_i	Water risk index for plant parts i;
K	Number of plant parts.

5.8. Determination of the real risk for a site

The actual risk for a site can be determined in the following way:

$$RRS = M1 + M2 + M3 + \lg(10^{WRI_S} \bullet ARSite) = M1 + M2 + M3 + \lg(EQ3_S \bullet ARSite)$$

RRS	Real Risk of Location;
$ARSite$	Average risk of location;
$WRIS$	Water risk index for location;
$M1$	Danger of earthquake;
$M2$	Danger of flood;
$M3$	Sensitive area;
$EQ3S$	Equivalent EQ3 of location.

The calculation is similar to the the one in Section 5.6.