RIDAS

Hydropower Industry Dam Safety Guidelines

Revised 2011

The industry guidelines for dam safety have been translated to enable wider dissemination of the guidelines to a broader public. However, the translation should not be considered as the official version of the guidelines. In the event of discrepancies between the two, the Swedish version shall take precedence.

Svensk Energi – Swedenergy – AB

Dam safety work is constantly undergoing development. Several development initiatives have been taken over recent years, for example, the work on design flood guidelines connected to a changing climate.

The need for further developing recommendations and guidelines for dam safety work arose during the 1990s, which resulted in the publication of Hydropower Industry Dam Safety Guidelines, RIDAS, in 1997. Developing these guidelines was a major task involving extensive work.

Even back in 1997 the industry was certain that these guidelines would have to be revised after a few years. The first revision was carried out in 2002 and thereafter in 2008 as new editions of RIDAS were published during these years. There has been continuous development of the application guidelines related to RIDAS and the development trend will continue. RIDAS has also been used by dam owners outside the power industry.

During 2010 work was initiated based on views of the industry's work teams, experiences of pilot projects and system revisions from RIDAS with a review of the 2008 year's edition and related application guidelines, the results of which are now available.

The work was managed in project form with management and participation by Swedenergy's Dam Safety Committee and several dam safety specialists from member companies and with project management of Swedenergy.

The Board of Directors of Swedenergy has decided to adopt these guidelines for application by relevant member companies as of 2012.

Swedenergy, January 2012

CEO

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FOREWORD

The overall objectives of these hydropower industry dam safety guidelines are to:

- define requirements and establish guidelines for adequate and uniform dam safety,
- constitute a basis for a uniform evaluation of dam safety and identification of measures needed to improve dam safety by means of systematic self-inspection, and
- support authorities in their supervision of dam safety.

The general focus of these guidelines when they were first produced and when they were revised has been on:

- the hydropower industry dam safety policy
- consequence classification of dams and, in the 2011 revision, with emphasis on the term “severe strain on society” in the event of a dam failure
- situation analyses
- safety analyses
- established and documented working methods
- established competence requirements
- systematic recording of experiences
- continuous improvements
- transparency
- independent review

The main contents of the guidelines have been printed in bold in this document. These guidelines, called RIDAS (in Swedish: “Kraftföretagens riktlinjer för dammsäkerhet”, the Power Industry Dam Safety Guidelines) are supplemented by application instructions. These provide more detailed information on how the guidelines should be adhered to in practice.

Swedenergy has adopted these revised dam safety guidelines for application in the power industry as of 2012.

CHANGES COMPARED WITH PREVIOUS YEARS' GUIDELINES

Changes to RIDAS 2012 compared with the 2008 guidelines

In 2010, development work began on the 2008 edition, with associated application instructions, on the basis of opinions from industry workgroups, experiences and consequences from the pilot project “Special review” and from RIDAS system audits.

RIDAS 2012 has the same structure as before. In order to differentiate between dams with severe consequences in the event of a dam failure, the term “severe strain on society as a consequence of a dam failure” has been introduced. The importance of systematics, sustainability and quality in dam safety work has also been emphasised. Proposals for status control programmes and competence requirements have been developed in order to develop and further reinforce status control. Application instructions can be found in sections 3, 4, 5, 6, 7 and 8.

A number of essential supplements and changes are listed individually below:

- the implications of the policy have been developed on the basis of the term “severe strain on society” (section 2)
- clarification of the importance of working systematically (sections 2, 6)
- a new consequence class with associated criteria has been introduced in order to differentiate between dams where the consequences of dam failure are severe as regards probability of severe strain on society (section 3)
- developed competence requirements, mainly in respect of status control activities (section 4)
- function testing of systems linked to safe discharge has been introduced to the status control, and the term “survey” has been replaced with “comprehensive inspection” (section 6)
- proposals for frequency and content in the status control programme have been changed (section 6)
- developed system audit for the companies which have dams in the highest consequence class (section 8)

Changes to RIDAS 2008 compared with the 2002 guidelines

The revision of RIDAS 2002 was initiated by development of the application instructions since 2002, and by checking the contents of the guidelines with frequent users.

RIDAS 2008 was given a partly new structure in order to make the guidelines for dam safety work process-oriented. Some new tools which should form the basis of planning were introduced. In terms of content, the guidelines were changed as regards planning and the organisation of contingencies for adaptation to already established forms of cooperation with other organisations. Moreover, the guidelines for set undertakings in the form of certain self-inspection activities were changed so as to enhance situation adaptation in dam safety work.

A number of essential supplements and changes are listed individually below:

- what has been described as the background to the guidelines has been supplemented with safety issues also being affected by the attitudes of society and the general public (section 1)
- the fact that man, technology and organisation (the MTO perspective) constitutes important criteria for safe functioning of the dam has been emphasised (sections 1 and 7)
- the safety analysis has been introduced as a basic principle for analysis and evaluation of the safety of a facility (section 2)
- the tables relating to consequence classes has been reworked in order to include all damage in one table (section 3)
- a situation analysis constituting the collective concept for analysis of critical situations, an increased risk of dam damage and dam failure in connection with – among other things – emergency planning has been introduced (section 5)
- a basic rule has been introduced for the interval and scope of status control which involves adaptation of the requirement at the facility in question (based on assessed safety with regard to the current status of the facility) and then application of recommendations for the implementation of status control at facilities in each respective consequence class (which must be regarded as a minimum ambition level) (section 6)
- documented maintenance plans for status-controlled maintenance must constitute the results of implemented maintenance planning (section 6)

The revision of the guidelines also resulted in corresponding updating of the instructions. It was noted that further clarification and development of the instruction for section 3, Consequence classification, may be implemented as a result of further work.

DEFINITIONS

Discharge capacity
The ability of the discharge system under all conditions to control the flow through the reservoir by means of water discharge.

Emergency preparedness
Established organisation of additional own and cooperating resources which are always on hand in abnormal operating situations.

Dam
A barrier across a waterway for the purpose of storing, controlling and/or diverting water.

Dam failure/dam accident
A breach in a dam or its foundation that could result in the uncontrolled outflow of stored water, constituting a danger to people and property.

Dam safety
Dam safety refers to safety against the uncontrolled outflow of water from the reservoir (dam failure) that could result in damage or injury.

Design flow
The flow which a dam and its discharge system must be able to withstand and discharge respectively without risking serious damage to any part of the dam or its discharge system.

Operations
Operations and staff input for monitoring dam status and, where necessary, manoeuvring of its moving parts.

Damming limit
The maximum permitted normal water level according to a water-rights court ruling.

Self-inspection
The dam owner's operation for inspecting the current dam safety status and documenting the fact that it is compliant with laws and regulations and is in harmony with all the basic principles for the operation.

Fault reporting
Systematic reporting of accidents, incidents and non-conformances to a collective fault reporting system in order to make the most of experience gained.

Consequence classification
Analysis of consequences concerning the probability of severe strain on society, serious injury or loss of human life, and damage to the environment, local facilities and other financial values in the event of a dam failure.

Additional damage
The increase in losses and damage to the surrounding area caused by a dam failure over and above the damage which - for example - a high flow would have caused even if the dam had not failed.

Redundancy
Independent systems designed to maintain safe operation should standard systems malfunction.

Severe strain on society in peacetime
A severe strain does not refer to a specific incident in itself, but to a condition which may occur when one or more incidents develop or escalate, affecting several elements of society. This condition is of such an extent that serious disruptions occur to important local functions, requiring coordination of input from a number of different authorities and organisations so that the situation can be handled, thereby limiting the consequences.

Situation analysis
This is an umbrella term for a facility-specific analysis of critical situations, an increased risk of dam damage and dam failure.

Safety analysis
A basic analysis and evaluation of the safety of a facility in relation to set requirements.

Status control
The dam owner's control of the status of a facility.

Inspection
Official inspection to ensure that the current dam safety status of a dam is compliant with applicable laws and regulations.

Application instruction
Instructions for application of the guidelines included in RIDAS.

Maintenance
Operations which aim to constantly maintain the dam safety status of a dam.

1. BACKGROUND

1.1. General

Hydropower operations are regulated by laws, regulations and guidelines. Indirectly, the expectations of society and the acceptance of the general public also influence the possibilities of running hydropower operations. Although this is linked primarily with issues relating to environmental considerations, safety issues currently also influence the attitudes of society and the general public in respect of the operations in question. Therefore, it is absolutely crucial that safety issues be given priority.

General technical development at present is creating a strong foundation for compliance with both environmental and safety-related aspects at facilities. However, new criteria in the form of anticipated changes in climate must in particular be taken into account by means of continuous inspection of altered flows and, where necessary, adaptation to the same.

Swedenergy is of the view that dam safety issues are very important. With its operations in the field, the association wishes to achieve a high, uniform level of dam safety within all member companies. The present guidelines must form a foundation for uniform assessments and simplify identification of necessary measures to enhance dam safety, as well as being able to provide support for dam safety inspections by the authorities.

In February 1997, Svenska Kraftverksföreningen – the Swedish Association of Power Plants – adopted Hydropower Industry Dam Safety Guidelines, RIDAS. An initial revision of the primary RIDAS document took place in 2002 in accordance with the recommendation of the association. Following a review and updating of instructions belonging to the primary document and checking the content of RIDAS with frequent users, RIDAS has been revised again in 2008.

In 2010, development work began on the 2008 edition, with associated application instructions, on the basis of opinions from industry workgroups, experiences and consequences from the pilot project “Special review” and from RIDAS system audits. A new revision has taken place in 2011. The Swedenergy Board of Directors has decided to adopt these revised guidelines, to be adhered to by relevant member companies as of 2012. Work will be continuing under the auspices of the trade organisation for an instruction for the application of RIDAS.

These guidelines are not to be perceived as regulations; instead, they must be viewed as a means of support for the dam safety work of the respective member companies. The dam safety level prescribed by RIDAS must be followed, but deviations in methods to achieve this level are allowed if the criteria for this are described and documented. This will achieve constant improvements benefiting increased dam safety.

The present application instructions have been linked to RIDAS. The two documents are termed "RIDAS" below. The purpose of the instructions is to clarify the guidelines and describe how they can be met. The structure of the application instructions follows RIDAS. The division into two types of document has come about so as to facilitate updating of the instructions more easily when new knowledge has been acquired.

Consequence classification constitutes the basis for the application of RIDAS. Efficient dam safety work assumes meticulous status control. In the new edition, emphasis has been placed on the need for analysis in connection with classification and status control.

The need to manage risks when dealing with any shortcomings in dams within some of the technical areas dealt with in RIDAS may demand some form of risk analysis. This is particularly pronounced in connection with Comprehensive dam safety evaluation. Descriptions of how risk analyses can be carried out are provided in generally available publications.

1.2. Dam safety

Dam safety refers to safety against the uncontrolled outflow of water from the reservoir (dam failure) that could result in damage or injury.

Dam safety is an issue relating to the interaction between people, technology and society. Dam safety involves complex issues related to risks when building dams in lakes and waterways. The concept of dam safety is also a comprehensive notion of qualified, interdisciplinary operations focusing on minimising accident risks and the consequences of actual accidents. This involves focusing on reducing both the probability of dam failure and its consequences.

The guidelines are applicable to all dams. The application of the guidelines is based on the consequences of dam failure. Classification of dams with regard to consequences in the event of dam failure constitutes the foundation for application of RIDAS. This means that the most stringent requirements are specified for systematics and quality in dam safety work for dams with regard to consequences in the event of dam failure involving a severe strain on society.

These guidelines are not to be regarded as laws, regulations or suchlike; instead, they must be viewed as a means of support for the dam safety work of the respective member companies. Any deviation from the guidelines and criteria for this will be reported and documented. It is assumed that application of the guidelines will lead to development of better solutions. Most importantly, the spirit of the guidelines must permeate the dam safety work of the respective member companies.

The safety of a dam is dependent upon the function of the subsystems in the dam and the function in the organisation that is responsible for operation of these systems. Good conditions for safe operation of the dam are created by taking into account the aspect of good constructional design with regard to people, technology and organisation (the PTO perspective).

A dam is - by definition - to be regarded as safe when it meets accepted safety criteria and the risk of dam failure is at an acceptable level.

1.3. General distribution of roles

The aim of dam supervision by the authorities is to secure adherence to the Swedish Environmental Code and the regulations issued on the basis of this Code. To this end the supervising authority must, as required, check compliance with the Code and regulations, permissions and other decisions issued on the basis of the Code, and also take the necessary corrective action. Also, the supervising authority must create the conditions required to facilitate compliance with the Code, with advice, information and so forth

The local county administrative board acts as the supervising authority for water operations and water facilities, including dam safety. The county administrative board is also responsible for supervision of the municipal rescue services and has the right to appoint rescue leaders and take over responsibility from the rescue services in certain, more extensive situations.

The municipalities are responsible for the planning and execution of rescue services, e.g. in case of high flows and flooding which can be caused by heavy rains or dam failure. Should a dam failure and/or flood occur, it is the responsibility of the rescue services to prevent or limit injury to people and damage to property and the environment. However, national services and municipalities are obliged to launch rescue operations only if this is motivated by the need for fast action, the importance of the object under threat, the costs for the action or other circumstances.

Svenska Kraftnät, supervisory guidance authority, must - among other things - promote dam safety in Sweden in accordance with its instruction from the state. To support its operations in the fields of dam safety and high flood waters, Svenska Kraftnät has appointed an advisory committee, Dammsäkerhetsrådet, the Dam Safety Council. Svenska Kraftnät is also supporting the county administrative boards in their work by – for instance – compiling procedures for the supervision, follow-up and reporting of dam safety.

SMHI, the Swedish Meteorological and Hydrological Institute, is responsible for meteorological and hydrological forecasting and warning services, and in some cases also for supervising the monitoring of water regulations issued in water-court and environmental court rulings.

At present, Swedenergy, SveMin (the mining industry) and Svenska Kraftnät are responsible for guidelines concerning determination of design flows for dam facilities. The dam owners, Svenska Kraftnät and SMHI have created a consultation arrangement concerning the adaptation and development of dam designs with regard to hydrological criteria.

General dam safety issues are handled between dam owners in a Dammsäkerhetskommitté – or Dam Safety Committee – appointed by

Swedenergy. Swedenergy is also a cooperation body concerning the development and application of RIDAS.
In dam safety work, it is important to keep the roles of the various organisations apart. The central role of the dam owner in dam safety work is fundamental to “the Swedish model”. The dam owner is always responsible for “safety against the occurrence of uncontrolled outflow from the dam”. Furthermore, the respective county administrative board holds responsibility for supervision, while the relevant municipality holds responsibility for the rescue services. Svenska Kraftnät has a role in promotion of dam safety, and its job also includes supporting the county administrative boards in their supervisory roles.

1.4. Dam owner responsibility

According to the Environmental Code, anyone owning a dam is responsible for maintaining it so as to safeguard against damage on public or private property or interests following an alteration of water conditions. The dam owner holds overall responsibility for dam safety.

Dam owners must comply with applicable legislation, national regulations and instructions on dam safety.

Dam safety must be maintained in accordance with the hydropower industry dam safety policy and be of a preventive nature.
Operations must be run in a manner which allows the current dam safety status of the facility to be known and documented, to be compliant with laws and regulations and to remain in harmony with all the principles forming the foundation for the operations. This, among other things, means that anyone responsible for the maintenance of a dam building (usually the dam owner) must formulate and comply with self-inspection procedures. Further, the dam owner must be aware of the consequences that would result from malfunctions. Should a dam failure occur, the dam owner is strictly liable for the consequences. Normally this means that the dam owner will be liable to pay damages, regardless of what caused the failure.

Dam owners must ensure that all work relating to dam safety is carried out by competent personnel.

When dams are sold to new owners or decommissioned, all available documentation is to be handed over with the dam.

In accordance with applicable legislation and rules, the dam owner is obliged to report to supervisory authorities and municipalities according to the Environmental Code and the Swedish Accident Prevention Act.

- In accordance with the Environmental Code (self-regulation ordinance), disruptions and similar incidents which can lead to nuisance for human health or the environment must be reported by the dam owner to the county administrative board.
- In accordance with the Swedish Accident Prevention Act, in the event of an accident or when there has been a risk of an accident, the

owner of the facility or the business operator must immediately notify the municipality in which the dam facility is located, as well as the Swedish Civil Contingencies Agency.
- In accordance with the Environmental Code, there must be procedures for reporting dam safety from the dam owner to the county administrative board.

2. BASIC PRINCIPLES

2.1. The hydropower industry dam safety policy

Swedenergy has established the following dam safety policy:

> Member companies' dam safety work focuses as far as possible on **protecting human life and health and protecting society from severe strain**, but also takes into account other protection needs.
>
> The dam safety requirements are related to possible consequences should a dam failure occur.

This means that:
- *the probability of dam failure in which severe strain on society and loss of human life* can be expected must be kept at the lowest possible level
- *the consequences of a dam failure* must be reduced as far as possible through good planning
- *dam safety* must be kept at a good international level

Dam safety work is carried out in a quality-assured manner and must be characterised by continuous improvements.

In practice, it is assumed that:
- work will be carried out responsibly and in accordance with applicable laws and regulations
- initiatives will be controlled and prioritised on the basis of safety evaluations based on analyses of dam facility status and the consequences of a dam failure
- the management of dam safety work will be carried out systematically, adopting a long-term perspective
- there will be interaction with relevant authorities.

2.2. Consequence governance

Dam safety work must be carried out in a manner governed by consequences, which means that all dams will be classified with regard to the consequences of a dam failure. In this regard, the probability of severe strain on society, serious injury or loss of human life, and of other damage to social, environmental and financial values which may arise in the event of a dam failure must form the basis of this classification.

2.3. Safety analysis

The structure of these guidelines is based on a system and function concept in which the significance of each system, subsystem and component with regard to dam safety is analysed and evaluated with a view to providing an overall view of the safety of the facility.

2.4 Quality assurance of dam safety work

Dam safety work must maintain good quality in planning, design, construction, operation, emergency preparedness, status control and maintenance. Established quality assurance principles are applied.

2.4.1 Documentation

Data for essential decisions in respect of dam safety work, such as establishment of a consequence class, must be documented.

2.4.2 Established and documented working methods

Working methods for all existing and planned activities must be established and documented at every facility.

2.4.3 Established competence requirements

Competence requirements must be defined and include information on training and experience. The competence of any staff involved must be documented.

2.4.4 Systematic reporting/experience feedback

The operation must be systematically be adapted to the needs occurring during ongoing control and analysis of dam status, and take into account experience gained. Non-conformances, incidents and accidents must be reported to the power industry's fault reporting system.

2.4.5 Ongoing dam safety improvements

Dam safety work must be characterised by ongoing improvements. Attempts must be made to adopt a proactive, long-term approach. The long-term approach is secured by means of initiatives such as research and development in the hydropower industry and in joint projects with partners.

2.4.6 Independent review

Repeated audits will take place in order to ensure that dam safety reviews are implemented which are independent of the dam owner in question. These audits should be executed in a manner that creates confidence and with maximum transparency.

3. CONSEQUENCE CLASSIFICATION

3.1. General

Dam safety work is governed by consequences. Therefore, dams must be classified on the basis of the consequences that may result from a dam failure.

Dam safety work governed by consequences means that requirements for initiatives to promote safety are adapted to the consequences of a dam failure and that available resources are used where they will be of most benefit in respect of dam safety. In line with this, each dam is classified with regard to the assessed consequence of a dam failure.

This classification is based on the marginal consequence; that is to say, additional damage resulting from a dam failure. The damage referred to in this context is the increase in the damage to the surrounding area caused by the collapse of the dam, over and above the damage which a high flow, for example, would have caused even if the dam had not collapsed.

The consequences of dam failures are assessed in respect of the probability of:

- severe strain on society
- serious injury or loss of human life
- other damage to the environment, societal facilities and financial values

Where there are several dams in one and the same facility, these are each classified individually. Thus individual dams in one and the same facility may have different consequence classes.

The dam's consequence class determines which dam safety requirements need to be met.

3.2. Dam failures, sequences of events and consequences

During classification, the evaluation of potential damage/injury should be based on a detailed flood study based on the most serious of dam failures occurring. The degree of detail in the study is governed by how difficult it is to assess the potential consequences of a failure, along with how conservative one is with assessments.

The consequences of a dam failure are assessed for both normal situations and high flow situations. If the dam is situated in a waterway with a number of dams, the consequences in the event of a continuous dam failure (domino effect) are also assessed.

3.3. Consequence classes

A system consisting of four consequence classes must be used for dam classification: 1+, 1, 2 and 3, 1+ corresponding to the most serious consequences of a dam failure.

The consequence classification system is shown in Table 1 below. This table takes into account the probability of severe strain on society, serious injury or loss of human life, and the social, environmental and environmental values that may be lost in the event of a dam failure. The table showing the most serious consequences determines the consequence class to which the dam belongs.

Consequence class	**Consequence of dam failure, expressed as probability of damage/injury**
1+	The probability of severe strain on society due to the overall effect of the damage along the waterway is high: • Loss/destruction/loss of serviceability of human life, the homes of many people, cultural environment and workplaces due to water • Serious disruptions to the country's electricity supply • Serious disruptions to communications and transport • Destruction of or extensive damage to other facilities important to society • Destruction of significant environmental values • Enormous economic damage
1	The probability of serious injury or loss of human life is not insignificant. *or* Considerable probability of severe damage to • important societal facilities • significant environmental aspects *or* High probability of: • great financial damage

2	Not insignificant probability of considerable damage to • societal facilities • environmental values *or* • financial damage
3	(There is negligible probability of damage as stated above)

Table 1 Consequence classes relating to the probability of serious injury or loss of human life, and of damage to the environment, local facilities and other environmental values.

High probability means that an expert assessor considers it to be high probability that damage/injury of this type will occur.
Not insignificant probability means that it is far from certain that this loss/damage may occur but that it is not possible to rule it out and so the possibility has to be taken into account.
Considerable probability–, finally, is considered to cover the range between high probability and not insignificant probability and corresponds fairly well to what is known in common parlance as fairly high probability to fairly little probability (see also Guidelines for determination of design flows for dam facilities).

3.4. Classification, assessment of damage and losses

The evaluation of damage/injury and losses required for classification is based on an assessment of any consequences in the form of severe strain on society, serious injury or loss of human life and damage to social, environmental and financial considerations which may arise in the event of a dam failure. Please see the application instructions concerning implementation of the assessments.

4. ORGANISATION, COMPETENCE AND WRITTEN EXAMPLES

4.1. General

The owner of a dam facility must ensure that dam safety work is organised in an expedient manner and that everyone active in the dam safety organisation has the requisite competence plus written examples for their work.

4.2. Organisation and competence

The organisation and allocation of responsibilities regarding dam safety must be established and documented.

Staff engaged in the operation, stand-by staff, status control, maintenance and project work for dams must have the appropriate competence for the task. Staff competence must be documented and include information on training and experience.

The person responsible for dam safety, the **Dam Safety Responsible**, must be named in the organisation, as must the **RIDAS Manager** and **Technical Dam Expert**.

Other key dam safety personnel Key dam safety staff include water regulation operators, operations managers/supervisors, remote monitoring and control, operation and maintenance and stand-by staff. Engineers, technicians and control facility staff working with dam safety functions can also be included.

Dam owners are responsible for ensuring that staff tasked with operating, monitoring and maintenance of dams have the resources and authority needed to do their jobs. This is applicable irrespective of whether these tasks are carried out by the dam owner's own staff or by staff employed by an associated contractor.

4.3. Manual concerning operation, status control and maintenance (DTU manual)

Every facility must have a specific manual containing all the necessary written examples in the form of documentation, procedures and

methods for the dam owner's operation, status control and regular maintenance.

The purpose of this manual is to ensure that qualified operating personnel, not necessarily familiar with the facility in detail, are able to assist with operation of the facility and provide other staff categories with a foundation for inspection, survey and more comprehensive dam safety evaluations.

Procedures and regulations linked directly to dam safety must be documented and compiled in the manual. This manual must include, or refer to, documentation necessary for the dam owner's operation, status control and maintenance of the dam.

Facility-specific operating instructions must be compiled which cover all operating situations. The manufacturer's maintenance/operating instructions must also be available if so deemed necessary.

The manual must include details on allocation of responsibilities and the relevant organisation for dam safety work.

The manual describes procedures for review of the manual and who is responsible for this. Reviews are carried out as required. Details in the hydropower industry's collective dam register will be updated if changes are made. Circumstances worth reporting are also returned to the fault reporting system

If possible, a copy of the manual should be made available at the facility.

5. OPERATION AND EMERGENCY PREPAREDNESS

5.1. General

Operation implies any action taken for the planning, monitoring and handling of a hydropower plant. Thus the word “operation” describes, as regards dams, operations and staffing resources for dam status monitoring and manoeuvring of moving dam parts, such as floodgates. The regular organisation is normally responsible for safe operation of the dam.

Planning measures must be implemented in order to meet the need for organisational backup in abnormal operating situations and if there is a risk of dam failure. These measures must lead to staffing and equipment being available. The company's procedures for crisis management include the risks which must be managed by dam owners.

5.2. Operating status

5.2.1 Normal operation

Reservoirs are handled safely by means of standard operations. Operating instructions for normal operation are applied. Normal and planned status control and maintenance measures are executed.

5.2.2 Extraordinary operation (at high inflows, etc.)

Reservoirs must be managed in a manner ensuring the safe handling of high flows up to the design inflows. Limitations as to reservoir handling must be documented.

During the flow seasons, facilities must normally be in a condition to be able to discharge the flows for which it has been dimensioned. Any limitations to discharge devices are reported and documented. The operating instruction indicates how safe operation is maintained during high flows.

5.2.3 Disrupted operation (in critical situations, etc.)

Operating instructions must state how operation is to be carried out in critical situations with a risk of dam failure or following a breakdown. The operating instruction must state ways of mitigating the consequences, any limitations as to possible overflowing or the fast tapping of the reservoir, and the downstream consequences of increased flows. Actions prior to a feared dam failure or following a dam failure are described in a separate Emergency Preparedness Plan (see section 5.3 Emergency Preparedness, below).

5.3. Emergency preparedness

5.3.1 Contingency plan

The dam owner must have good emergency preparedness measures in place so as to handle situations which may lead to dam failure or otherwise uncontrolled outflows, resulting in a risk of serious injuries to people or serious damage to the environment and valuable property, and so as to minimise the consequences should a dam failure occur. Rules and procedures for work and actions in such situations must be established and documented in an Emergency Preparedness Plan.

Actions following and prior to a potential dam failure must be described in an Emergency Preparedness Plan. This plan must specify the organisation, responsibilities and boundaries with external organisations. The Emergency Preparedness Plan must also state what operating measures should be undertaken, and what staffing and equipment are available to prevent dam failure in the first instance, or to mitigate the consequences of such a dam failure as far as possible should one occur. The objective is to minimise injuries and damage to valuable property and the environment that may result from any dam failure. Besides good planning for his own initiatives, the dam owner's emergency preparedness also includes information for and cooperation with the rescue services and other parties concerned.

The scope of emergency preparedness and degree of detail in the plan must be adapted to suit the consequence class of the dam.

With the legal support of the Ordinance concerning protection against accidents (FSO), the county administrative board may decide that a dam facility has to be compliant with the Civil Protection Act (LSO). The owner of any such facility or anyone performing operations at the dam facility is liable to maintain emergency preparedness measures to a reasonable extent in order to protect against accidents or limit serious injury to humans or damage to the environment caused by an accident.

5.3.2 Dam owner's emergency preparedness planning

Emergency preparedness planning is used for advance formulation of well thought-out, functional procedures for mobilising the requisite resources when situations arise which could involve dam failure as the ultimate consequence. Documented action plans based on situation analyses implemented must exist for critical situations, where there is an increased risk of dam damage and dam failure.

The purpose of emergency preparedness planning is to use prepared methods:

- to minimise the risk of dam failure occurring

- to minimise the consequences should a dam fail
- to reduce the risk of incorrect decisions and measures in critical situations
- to ensure good utilisation of available resources
- to identify and ensure responsibilities at various levels
- to ensure that everyone within the organisation receives necessary information.

The results of emergency preparedness planning must consist of a EPP as outlined above which also includes action plans for facility-oriented measures in the event of an increased risk of dam damage/dam failure or if a dam failure has occurred. All actions following and prior to a potential dam failure must be described.

At the preparation stage, all abnormal incidents which may involve a risk of injury to humans or damage to the facility and/or the environment must be identified, evaluated and analysed as far as possible. Abnormal incidents also include damage to the facility which may result from trespass or sabotage. These results constitute a basis for planning.

Once emergency preparedness planning has been completed, exercises involving cooperating functions must be carried out in order to verify that the EPP will work in a practical situation.

The EPP is reviewed when so required. The EPP may need to be updated when the DTU manual is updated, and vice versa.

5.3.3 Cooperation on emergency preparedness planning

For effective emergency preparedness planning, cooperation, planning, information and communication must take place with parties that would be affected in the event of dam damage.

Dam owners, water regulating enterprises, county administrative boards and municipal rescue services are the primary parties.

Cooperation between these primary parties is based on the extent of the potential consequences in the event of dam failure.

Planning aims to ensure that all parties cooperating are better prepared. This creates a better understanding of what can happen and provides a firmer foundation for doing the right things as a result of completed planning initiatives.

The information on which planning is based must be appropriate in terms of scope and degree of detail and match the requirements of the parties. In specific terms, the need for information often deals with what changes in water level, etc. would be caused by a specific dam failure.

Communication in accordance with well thought out alarm plans is a must in order to ensure a link between parties that functions well in an emergency.

6. STATUS CONTROL, FAULT REPORTING AND MAINTENANCE

6.1. General

Anyone owning a dam is responsible for maintaining it so as to safeguard against damage on public or private property or interests following an alteration of water conditions. The dam owner holds overall responsibility for dam safety.

6.2. Dam owner's status control

6.2.1 General

Dam owners must carry out status controls for the dams for which they are responsible.

The purpose of the dam owner's status control is to constantly monitor and check the current status of a dam in relation to its original status or functional requirements, along with any changes to laws and guidelines.

6.2.2 Status control

When checking the status of a dam, the programme for this control must be based on the dam's consequence class and include the following activities:

- **operational supervision**
- **dam monitoring**
- **function testing**
- **inspection**
- **comprehensive inspection** (previously referred to as "survey")
- **comprehensive dam safety evaluation (FDU)**

How often these status control activities take place must be based on observations made of changes to the safe function of the dam, e.g. leaks measured, along with any changes made to the requirements.

The following section describes proposals for the frequency and content of a status control programme.

The results of each status control will be documented, followed up and reported in a manner appropriate for the control in question. Systematic description of status controls carried out must be documented regularly for each individual dam.

In the case of status controls which indicate a change in dam status, the dam owner must carry out appropriate analyses of how the change may affect dam safety, irrespective of the type of status control in which the change is noted. The purpose of these analyses is to provide the dam owner with data on what measures should be implemented in respect of dam safety. These dam safety analyses can also be used to locate the dam's weak points and provide data for improvement of dam safety in relation to its original level.

6.2.2.1 Operational supervision

Operational supervision of dam elements vital for safety is performed at a frequency and scope adapted to suit the facility-specific needs for monitoring. This supervision is often coordinated with operational supervision of other elements of a facility and is normally carried out once a week.

The purpose of operational supervision is to reveal changes which may affect the safety of the dam.

An instruction or checklist must describe and document the scope and focus of operational supervision. This instruction is updated as required in connection with inspection or survey so that the most significant aspects for dam safety are given priority. This instruction must also describe how operational supervision is to be adapted to suit - for example - the season, water level, extreme weather conditions or other facility-specific conditions. Reporting procedures must be established and documented.

Staff performing operational supervision must have the appropriate knowledge of dam function and safety, and a good knowledge of the dam in question.

6.2.2.2 Dam monitoring

A specific monitoring programme is compiled for every dam. This monitoring programme is updated as required. Reporting and evaluation procedures must be established.

The purpose of dam monitoring is to indicate changes and provide data for a long-term status assessment. Dam monitoring should also be able to provide early warnings based on safety analyses carried out.

The scope, frequency and type of measurements are adapted to suit the consequence class and the specific criteria for the dam. Dam measurements are carried out by staff with documented expertise.

6.2.2.3 Function testing

Function testing of discharge systems and other systems with associated subsystems is carried out with a view to verifying and maintaining high levels of safety/functionality. Function testing of the discharge system takes place at least once a year, ideally before a flow season. Function testing is carried out in accordance with a facility-specific instruction and/or checklist and is documented in a report. Function testing covers regular operating systems, auxiliary operating systems and protection and monitoring functions.

6.2.2.4 *Inspection*

Inspections are carried out twice a year for dams belonging to consequence classes 1+ and 1, and once a year for dams belonging to consequence class 2. When a comprehensive inspection or comprehensive dam safety evaluation is carried out, an inspection can be integrated with this activity.

The purpose of the inspection is to evaluate repeatedly any changes and verify safety.

Inspection, which includes all facility elements of significance to dam safety, must be described in an instruction and executed using a checklist. The inspection is documented in a report.

Inspections are carried out by staff with documented expertise in dam safety issues.

6.2.2.5 *Comprehensive inspection*

Comprehensive inspections are normally carried out once every three years for dams belonging to consequence classes 1+ and 1, and once every six years for dams belonging to consequence class 2.

The purpose of comprehensive inspection is to repeatedly acquire overall expect evaluations of measurement results, any faults/defects or other changes which form a basis for assessment of dam safety.

For new dams, the first comprehensive inspection must be carried out within the first three years of the start of damming.

The comprehensive inspection includes all facility elements of significance to dam safety. This means that for dams with extensive and/or advanced mechanical and electrical equipment, competence is required in the fields of construction technology, mechanics and electrics.

The comprehensive inspection includes execution of an analysis of the measurements collected over the year(s) and visual observations carried out from dam instrumentation and status control (the dam's measurement programme).

The comprehensive inspection is carried out by people with competence as specified in 4.2. The job of the Technical Dam Expert includes approval of the people carrying out comprehensive inspection by checking that they meet the competence requirements.

6.2.2.6 *Comprehensive dam safety evaluation (FDU)*

For dams belonging to consequence class 1+, comprehensive evaluation is carried out once every nine years, for dams belonging to consequence class 1 once every twelve years, and for dams belonging to consequence class 2, once every eighteen years.

The purpose of comprehensive evaluation is to establish the dam safety status, taking into account current safety requirements. Current safety requirements include changes in design flows for the dam in question, as well as any tightening-up of laws, regulations and standards.

This evaluation is a comprehensive, systematic analysis and evaluation of the safety of a dam facility based on a complete analysis of all safety components and the entire system. This evaluation includes comprehensive inspection/surveying of all dam elements, function testing and function assessment, evaluation of operating experiences, review and evaluation of design criteria and design documentation plus a DTU manual and EPP, taking into account current safety criteria and requirements. This evaluation also includes analysis of operating experiences and of the arrangement of safety work. An evaluation report is compiled.

Comprehensive evaluation is carried out by qualified personnel approved by the dam owner.

6.2.2.7 *Summary of proposals for status control programmes*

Table 2 below shows proposals for programmes for the status control of dams belonging to consequence classes 1+, 1 and 2. The dam owner formulates a programme for status control of dams belonging to consequence class 3.

Consequence class **Status control**	**1+**	**1**	**2**
Operational supervision	Continuous	Continuous	Continuous
Dam monitoring	Continuous	Continuous	Continuous
Function testing	Once a year	Once a year	Once a year
Inspection	Twice a year	Twice a year	Once a year
Comprehensive inspection	Once every three years	Once every three years	Once every six years
FDU	Once every 9 years	Once every 12 years	Once every 18 years

Table 2 proposals for programmes for the status control of dams belonging to consequence classes 1+, 1 and 2.

6.3. Fault reporting

Circumstances of any significance are reported to the hydropower industry incident reporting system. The application instructions describe how faults or defects and incidents occurring are to be assessed.

The purpose of reporting is primarily to compile a collective bank of experiences which provide opportunities for individual dam owners to implement continuous improvements. Experiences reported can also be utilised as a foundation for joint statistics and evaluations in the industry.

A system for assessment of non-conformances is applied during reporting.

6.4. Maintenance

6.4.1 General

Dams must be maintained to the extent required to continuously uphold the dam safety status. Maintenance is planned and executed systematically.

The purpose of the dam owner's maintenance is to use preventive measures governed by status to maintain the dam in its original condition. When measures governed by status are implemented, measures designed to enhance dam safety and governed by changes in criteria for the safe function of the dam over a longer perspective are also implemented where required.

6.4.2 Maintenance planning

Maintenance must be based on the results of a completed status control and dam safety requirements laid down in laws and guidelines.

Measures governed by status are planned and implemented to an extent dependent upon the current dam status and function in relation to its consequence class and requirements for general safety. Measures governed by status and intended to enhance dam safety can ideally be planned from a long-term perspective.

Preventive measures are governed by internal instructions and with the aid of relevant documentation from designers, manufacturers and suppliers.

All maintenance planning must take place in action plans intended for the purpose. Maintenance initiatives implemented are documented and filed. The DTU manual includes general notes concerning maintenance carried out and measures implemented to enhance dam safety.

7. DAMS, SYSTEMS AND DESIGN

7.1. Technical dam system function

7.1.1 General

Dams normally consist of several elements which form a system in terms of function. The function in this system is dependent on the function of the dam elements. Therefore, when analysing the safety of a dam, this must be regarded as a composite system function, the safety of which is dependent on the safety on the function of the subsystems.

Dams are dimensioned so that they can counter - with no damage that may jeopardise safety - all possible loads to which they can normally be expected to be subject over their service life. Dams belonging to consequence classes 1+ and 1 must also have the ability to withstand, without failing, highly unlikely but possible circumstances that may arise. However, damage may be accepted.

Design loads which are discussed in application instructions may differ as regards consequence classes.

7.2. Embankment dams

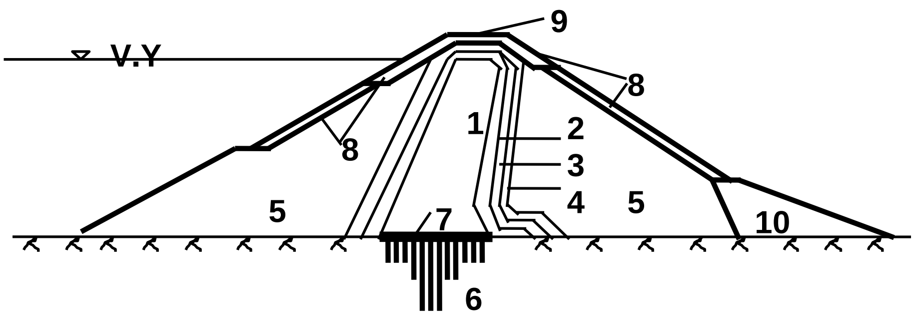
7.2.1 General

In these guidelines, embankment dams are understood to be dams consisting mainly of packed soil and/or rockfill.

Embankment dams are usually made of a number of zones with different properties and functions:

- a sealing zone to stop water from flowing through the dam,
- filter zones to prevent fine matter from being transported away from the sealing zone,
- supporting zones to provide dam stability,
- erosion protection at the outer parts of the slopes, protecting against attacks from waves, ice, precipitation and, to a limited extent, flooding and water spilling over the crest.

Figure 1 shows the various components of a standard Swedish embankment dam with a central impervious core.



Figur 1

1.tätkärna; 2.finfilter; 3.mellanfilter; 4.grovfilter; 5.stödfyllning; 6.injektering; 7.ev.särskild yttätning; 8.erosionsskydd; 9.dammkrön; 10.tåförstärkning

7.2.2 Dimensioning

Dams must be located and have a principal design so as to allow general requirements concerning impermeability, stability, durability and safety to be achieved for both normal and exceptional loads at a reasonable cost.

7.2.3 Design and structure

The general requirements to be made of each part of the structure are stated below. The requirements must correspond to the consequence class of the dam in question.

7.2.3.1 Foundation

The foundation must be laid on a bed of adequate evenness, impermeability and supporting capacity for the dam body.

The dam is designed for safe interaction with the foundation. The foundation must, where necessary, be drained to eliminate the risk of leakage, internal erosion and instability.

Connecting concrete structures are designed for good interaction with the embankment dam.

If the foundation does not meet the requirements, it is sealed and/or reinforced.

Since the impervious core is often susceptible to erosion, it must be established with certainty that the rock bed has no open cracks interfacing the impervious core.

7.2.3.2 Impervious core

The impervious core of the dam must be made of materials that provide an adequately longlasting homogeneity and impermeability in accordance with the design, dimensions and structure of the dam.

The structure and materials must be adapted to other zones and the foundation to ensure good interaction.

Particular attention must be paid to sensitive parts of the dam, such as interfaces with the foundation and concrete structures, and interfaces with filter zones.

7.2.3.3 *Filters, intermediary zones and drainage*

Requirements concerning materials and filling methods ensuring adequate function will be established for each dam section in accordance with its consequence class.

Filters are used to filter seepage and thus prevent the emergence of inner erosion, drain the impervious core and, if needed, also the supporting fill, as well as adding to the self-sealing properties of the dam in the event of major leakage from the upstream side.

7.2.3.4 *Supporting fill*

The supporting zone is designed and built to ensure, with an adequate margin, the overall stability of the dam under all design load conditions. The stability is verified.

Dams belonging to consequence classes 1+ and 1 must have supporting and draining zones ensuring the persistence and stability of the dam in the event of any conceivable leakage through the foundation, the impervious core or the filter zone above the impervious core. Securing the dam toe is particularly important.

7.2.3.5 *Erosion protection*

Erosion protection is dimensioned to withstand the effects of waves, ice, ground frost and other potential stresses. The design wave height governs the design of erosion protection.

When the erosion protection is made up of stone/boulders, these must be sufficiently large and durable. All requirements for filters must be met with regard to the material inside. The erosion protection must also protect the surrounding natural terrain from the harmful effect of waves so as to prevent subsequent damage to the dam structure.

7.2.3.6 *Dam crest*

The crest is designed and built to prevent harmful ground frost from damaging the impervious core and to allow the dam to withstand waves washing over it, as required.

The dam crest is broad enough to secure necessary space for underlying material zones. The crest is also even enough to facilitate the observation of any changes.

7.2.3.7 Excess height

Dams are constructed with sufficient excess height to compensate for anticipated subsidence.

7.2.3.8 Freeboard

Dams must have enough freeboard to prevent waves, in combination with wind set-up or any other temporary washing-over, from washing over the crest and causing damage.

The distance between maximum water level and the safe washing-over level of the dam must exceed any possible washing-over in connection with design flood situations. The safe washing-over level is established for each dam individually.

7.2.4 Instrumentation

The dam must have instrumentation permitting monitoring and follow-up of status and any changes, adapted to its consequence class.

Embankment dams must have instrumentation to the appropriate extent, partly to verify at initial damming any assumptions made during planning, and partly to provide information in the short and long term of any changes which will affect dam safety.

7.2.5 Construction documentation

The structure is based on detailed drawings and working instructions adequately describing the specific requirements for the dam in question.

7.2.6 Structure

Dams are built in compliance with construction documentation and in a professional manner. Non-conformances must not exceed applicable tolerances.

7.2.7 Controls

Systems ensuring testing, control and review of all important phases and elements when building an embankment dam must be in place. Quality assurance must be carried out according to applicable standards, regulations and control plans. The control plan must cover the period up to final building inspection approval and/or the first dam survey.

7.2.8 Documentation

Design documentation, including design criteria, important considerations, calculations and approved drawings, along with the results of inspections carried out, including any non-conformances and

associated measures, plus any other valuable information influencing the status of the completed structure must be documented and filed.

7.3. Concrete dams

7.3.1 General

This section is applicable to concrete dams and concrete structures forming parts of dams. This guidelines is based on a traditional way of dimensioning concrete dams. Development is in progress on a transition to reliability-based dimensioning.

Concrete dams can be divided into gravity dams and arch dams. Gravity dams occur in several different designs, homogeneous dams being the most common, as well as – in older structures – solid, stone-clad "rammed concrete dams" and buttress dams.

Dams and any related structures are dimensioned, designed and constructed to meet reasonable impermeability requirements and with sufficient ability to withstand the loads and deformations influencing stability, function and strength during construction of the dam structure and over its service life.

Important applicable standards are detailed in the application instructions.

7.3.2 Dimensioning

Verification of the fact that the requirements on bearing capacity, stability and durability are met must take place by means of calculations, testing or a combination thereof.

7.3.3 Design and structure

The general requirements to be made of each part of the structure are stated below. The requirements must correspond to the consequence class of the dam in question.

7.3.3.1 Foundation

Concrete dams must be placed on bedrock where technically and financially feasible. Exceptionally, the foundation could also be laid on some other bearing material having or having been given adequate strength and impermeability.

Where necessary, the bed is injected and drained to lessen the pore water pressure and flow of water which could lead to instability.

The bed surface is designed to ensure adequate constructive interaction between bed and dam.

7.3.3.2 Expansion joints

Concrete dams have a required number of movement joints. Sectioning must be carried out in a manner and to the extent that harmful crack formation is prevented.

The joints must be adequately watertight and sufficiently durable. These must also be able to absorb any loads occurring where appropriate.

7.3.3.3 Freeboard

The distance between the maximum water level and the top of the dam crest must be adequate to prevent waves from washing over the crest, causing damage.

Many concrete dams and floodgates are able to withstand waves washing over. This is acceptable if the stability is verified and the dam foundation and areas affected downstream are protected against erosion that could damage the dam.

7.3.4 Materials

Component materials, fresh concrete, hardened concrete and reinforcement must have such properties as to ensure the intended bearing capacity, stability and durability for the finished structure.

These properties are verified by means of testing or some other appropriate manner.

7.3.4.1 Concrete

The concrete must meet the requirements of applicable standards.

The concrete's watertightness, strength, frost resistance and ability to withstand chemical attack are of utmost importance.

7.3.4.2 Reinforcement

The reinforcement must meet the requirements of applicable standards.

Protection against corrosion is very important. Concrete meeting the requirements as stated above is expected to have a minimum of cracks, providing good protection against corrosion when combined with an adequate sealing layer.

7.3.5 Instrumentation

The dam must have instrumentation permitting monitoring and follow-up of status and any changes, adapted to its consequence class.

7.3.6 Construction documents

The structure is based on detailed drawings and working instructions adequately describing the specific requirements for the dam in question.

7.3.7 Structure

Dams are built in compliance with construction documentation and in a professional manner. Non-conformances must not exceed applicable tolerances.

7.3.8 Control

Systems ensuring review and control of all important phases and elements when building a concrete dam must be in place. Quality assurance must be carried out according to applicable standards, regulations and control plans. The control plan must cover the period up to final building inspection approval and/or the first dam survey.

7.3.9 Documentation

Design documentation is documented and filed. This must include design criteria, important considerations, calculations and approved drawings, along with the results of inspections carried out, including any non-conformances and associated measures, plus any other valuable information influencing the status of the completed structure.

7.4. Discharge systems

7.4.1 General

The water discharge systems of a dam must be of robust design and structured to meet dam safety requirements in all regards, both facility-specific and dependent on the current consequence class.

The documentation for dimensioning is available in *Guidelines for determination of design flows for dam facilities*. In addition, the system structure must be designed to ensure the requisite reliability in the system.

A safe discharge system has the following properties or characteristics:

- a system structure which meets the requirements for good design, taking into account the man, technology and organisation (MTO) perspective.
- reliability and maintainability are in relation to the criteria for the facility.
- adequate resistance to landslides, earthquakes, erosion and cavitation, plus adequate wall height, so as to ensure safe discharge of the design flow.

- adequate energy conversion to prevent undermining or any other erosion that could pose a threat to the dam or spillways, at any flow up to the design flow.

- adequate capacity for or an effective barrier against floating debris, designed to withstand any load occurring.

- adequate resistance to hydraulic forces that may affect the discharge system.

- adequate capacity for or an effective barrier against any possible ice conditions in the reservoir.

7.4.2 Reliability

The reliability of any discharge system is assessed by means of analysis of the reliability of every subsystem included in the system. For qualified assessments, application of the risk analysis methods utilised for analysis of the safety status of a dam is recommended.

7.4.3 Discharge capacity

7.4.3.1 General

The discharge system must fulfil its function in respect of capacity. When evaluating system capacity, conditions which may be suspected to influence the discharge system must be taken into account.

The discharge system in a dam must be dimensioned sufficiently well to withstand and discharge all flows up to the design flow, taking into account the duration of the flow, without risking serious damage to the dam.

7.4.3.2 Necessary discharge capacity

The necessary capacity of the discharge system is determined by the design flow at the point in the waterway where the dam is located. The design flow is established on the basis of Guidelines for determination of design flows for dam facilities.

7.4.4 System structure and design

7.4.4.1 General

The system is designed to ensure that there is little probability of the discharge system failing to operate or any other malfunction caused by any fault in the function chain. The availability of the discharge function is adapted to the consequence class of the dam.

The above system design requirements apply to the entire function chain required for discharge.

Examples of functions include:
- local power/auxiliary power
- cables/cable routing
- mechanical systems
- control and indication systems
- water level measuring systems

When there is risk of dam failure due to faults in the discharge function, necessary redundancy must be inherent in the function. The design capacity of redundant discharge systems is determined on the basis of the requirements of the facility.

The risk of environmental impact, fire, sabotage or any other external incidents are taken into account during system design and structuring and when choosing materials. Environmental impact refers to EMC (electromagnetic compatibility), rain, floating debris, wind, temperature, ice, animals, etc.

7.4.4.2 Mechanical systems

The mechanical equipment included in the discharge system (floodgates, drive machinery, etc.) must be able to withstand design loads with adequate safety.

Loads and deformations can be caused by water levels, floating debris, ice, vibration, etc. Ice pressure on floodgates may be disregarded, provided ice is kept away to the requisite extent.

During design, the possibility of floodgates sticking due to what is known as the drawer effect is observed.

7.4.4.3 Electrical systems

The electrical equipment included in the discharge system (local power, auxiliary power, cables, electrical drive systems and control/safety systems) must be able to withstand design loads with adequate safety and, if possible, include redundant functions in its system structure.

The availability of the electricity supply and hence the functionality of the discharge system is largely dependent on how the internal electrical distribution system of the facility is designed. An auxiliary power facility which works well is an important component in the system for class 1+ and 1 dams, as well as separate cable laying throughout the entire facility up to the component dependent on electricity. Redundancy in the control and safety systems is also essential for the reliability of the discharge system.

7.4.4.4 Auxiliary operating systems

Dams belonging to consequence classes 1+ and 1 must have auxiliary operating systems. These must not be used for other functions unless uptime can be assured.

It must be possible to commission auxiliary operating systems, taking into account the time requirements for safe discharge. Mobile units may be adequate if the time requirement permits acquisition of auxiliary operating systems, transport, connection and commissioning in all possible operating cases, including external circumstances such as snow, rain or wind, for example. Motor generator units, mobile cranes and decoilers are examples of auxiliary operating systems.

7.4.4.5 Control, indication and limit functions

Discharge systems are equipped with relevant functions for control and indication.
Remote-controlled discharge systems are equipped with devices which ensure that the facility element being controlled does not pass its outer positions.

The selection of functions and the design of the same take place according to the specific requirements of the facility.

7.4.4.6 Instrumentation

Discharge systems must have the requisite instrumentation.

The presentation of measurements (mechanical, electrical) for water levels, floodgate positions, etc. are of the utmost importance to operational safety.

Measurements of floodgate positions must be obtained as close to gate movements as possible. It must be possible to read gate positions must a control location.

For facility inspection and control purposes, it should be possible to read important operational measurements, e.g. oil pressure and flow values.

7.4.4.7 Automatic systems

When there is a stoppage at a power plant, the propulsive water flow must be discharged automatically and safely if so required for dam safety reasons.

At facilities with small reservoirs, this may be effected through the automatic opening of spillways. This equipment must be designed such that the facility-related criteria regarding permitted water rise and reduction rates, accuracy requirements, etc. are taken into account.

7.4.4.8 Protective systems

Dams belonging to consequence classes 1+ and 1 are equipped with a disaster protection function (KAS), unless there are special reasons. This should also be taken into account for dams in consequence class 2.
Protective functions must operate independently of automatic functions.

A low rise rate for the water level in the reservoir could allow for such an exception.

7.4.4.9 Monitoring and remote control systems

Discharge facilities for dams belonging to consequence classes 1+ and 1 are provided with relevant monitoring functions for the early detection of faults.
Dam facilities are provided with remote control systems with the requisite redundancy in the communications function where there may be a risk of dam failure if information fails to be transmitted to a control centre.

Dam facilities belonging to consequence classes 1+ and 1 must not be dependent solely on an operational remote control function for safe discharge. This means that there must be local functions/systems in these dam facilities for discharge, either automatic or manual.

Correctly designed monitoring systems are of the utmost importance for the detection and rectification of faults before these cause some kind of problem in the facility.

The most important task for the remote control system is, from a dam safety point of view, to transfer important information to the control centre. Normally this is carried out by transferring measurements regarding reservoir water levels, flows and floodgate positions, and by transferring alarms in the event of various kinds of fault. Alarms may include fault signals from e.g. gate manoeuvring and heating equipment, auxiliary power systems and water level measuring equipment. Remote control functions must be chosen and designed according to the requirements of the facility.

Any disruption or fault in the communications link with a dam facility must trigger an alarm at the control centre. Remote-controlled dam facilities belonging to consequence classes 1+ and 1 must also have a redundant communication method which ensures that alarms are transmitted to the control centre and/or on-call staff.

The remote control system should be able to operate the floodgates, unless there are special reasons. One such reason could be that the size of the reservoir always allows plenty of time for manual operation.

7.4.4.10 Heating and de-icing systems

Discharge facilities operated in winter must, if there is a risk of floodgates freezing or otherwise being affected by ice, have appropriate systems for heating and de-icing.

These systems may consist of guide way and gate heating , as well as de-icing, or a combination of these. The systems should have relevant monitoring functions.

7.4.4.11 Water level measuring systems

The water level measuring point must be designed to ensure that measuring takes place in a calm section of the reservoir, taking into account the water-court/environmental court ruling and the placing of the spillways. The risk of blockages, freezing and other environmental impact must be considered. Unless there are special reasons, water level measuring must have redundancy.

7.4.5 Operating instructions

Discharge systems are operated according to predefined instructions.

When establishing these instructions, a safe water discharge must be secured for all hydrological situations up to design flow. These instructions are documented.

In the event of high flows or at a time of the year when such flows can be expected, no work that could endanger safe water discharge may be carried out at the facility.

7.4.6 Testing

Discharge systems are tested at regular intervals.

These tests should, if possible, be carried out as full-scale tests, going from a fully closed position to a fully open one, permitting testing of limit position functions, among other things.

7.4.7 Documentation and labelling

Discharge systems must have the requisite documentation and labelling.

This documentation may comprise summary drawings showing systems layout, labelling, geographical position, and water discharge graphs and other data/information important to dam safety. The documentation must be available in floodgate/winch rooms, control rooms and control centres, as required.

Relevant, clear labelling must be present for both normal operation and emergencies.

7.4.8 *Access protection*

The facility must be provided with appropriate protection to prevent unauthorised access to sensitive elements of the discharge system and hence to reduce the risk of sabotage.

7.4.9 *Other*

The discharge system must be accessible to authorised staff all year round, irrespective of season, etc.

8. DAM SAFETY AUDITING

The fact that dam safety work is being carried out according to these guidelines is tested through audits of companies which own or manage dams belonging to consequence class 2 or higher. When auditing companies which own or manage dams in consequence class 1+, application of the guidelines will be examined in particular detail, including principles for safety, management and quality of dam safety work.

The independent audit is carried out by two auditors, with Swedenergy as their principal.

The auditors must have a good knowledge of the industry and good knowledge of RIDAS and the Environmental Code sections on self inspection, among other things.
Every company owning a dam must name a specific person (RIDAS manager) who is responsible for ensuring application of RIDAS in dam safety work.
The auditors must maintain mutual communication and contact with the RIDAS manager. The audit relates to the overall dam safety programme and work of the company.

The auditors report to Swedenergy.

Figure 2 The fact that dam safety work is being carried out according to these guidelines is tested through audits of companies which own or manage dams belonging to consequence class 2 or higher.