

New Norwegian Dam Safety Regulations

G. Holm Midttømme, L. Grøttå and E. Hyllestad

The Norwegian Water Resources and Energy Directorate, Pb 5091 Majorstua, N-0301 OSLO, Norway

E-mail: ghm@nve.no

Abstract

The first regulations for dam safety in Norway were issued in 1981 with focus on technical requirements for construction of dams. In the 1990s, requirements for dam owner's internal control, classification and qualifications were introduced. In 2001, the legal framework for dam safety was revised and 3 new regulations were issued with a legal basis in the Water Resources Act. After a few years, some of the requirements in the 2001-regulations proved to be difficult to administer, and the dam safety authority (The Norwegian Water Resources and Energy Directorate, NVE) decided to do some minor revisions. As the revisions progressed, it appeared that there was a need for new requirements and for clarification of some of the existing requirements, which increased the extent of the revisions. In January 2010, a new regulation on safety of dams and other hydraulic structures was issued. This regulation replaces the previous regulations issued in 2001 as well as the requirements for dam safety, which had a legal basis in The Energy Act and in the Civil Defence Act. This paper will give a brief overview of the background for the revision work and the content of the new regulations, with a special focus on the new requirements.

Introduction

In Norway, governmental supervision of dams to ensure public safety began 1909 with the establishment of a Control Department in the former Norwegian Water Administration, which was succeeded by the Norwegian Water Resources and Energy Administration (NVE) in 1920. Today NVE is a directorate under the Ministry of Petroleum and Energy.

During the first years of operation, the Control Department was responsible for supervision of 11 hydropower facilities. Today the function of the former Control Department is taken care of by the Section for Dam Safety in NVE. 3100 dams, including 341 large dams ($h > 15$ m), and 1600 waterways are subject to governmental supervision according to the official dam register. The dams are owned by 375 dam owners. Most of them are public companies owned by the State, counties or the municipalities. The main activities of the Section for Dam Safety are related to supervision of dams and appurtenant structures, including approval of plans for construction and

rehabilitation. Supervision of dam owners internal control systems, as well as administration and development of the legal framework for dam safety, including development of new technical guidelines, are also important activities. The main goal of the governmental supervision is to ensure a uniform high level of safety for Norwegian dams and appurtenant structures, and thereby ensure that these structures do not pose a threat to life, property or the environment.

Legal framework for dam safety before 2001

The former Control Department in NVE proposed a Supervision Act for dams in the first years after the department was established in 1909, but this act was never approved by the Parliament. Thus, in the period 1909 to 1981 the governmental supervision was based on general conditions given in the concessions (licenses) for hydropower development. In other words, the legal basis for the governmental supervision of dam safety was attached to the dams that needed concessions. Dams which were not subject to licensing were not supervised by NVE. As many of these dams could be quite large and thereby be a danger to downstream society if not safely constructed and operated, NVE tried for decades to change the legal basis of this situation. In 1940 a new act was issued giving NVE the legal basis to supervise dams that operated without concessions, if necessary. In 1982, the first Norwegian regulations for governmental safety supervision of all dams over 4 m height or with a reservoir volume larger than 500 000 m³ were issued.

Requirements for planning, construction and operation

Until the 1980s the safety level for planning, construction and operation of dams was given by technical standards and good engineering practice. In addition there were specific requirements for protection of hydropower facilities against war actions, which also included many dams, given by a Committee for Civil Defence for the Hydropower Sector in Norway (KSFN). This committee was established in 1948. Other legal requirements for planning and construction of dams were not given until 1981, when the first regulations for planning, construction and operation of dams (The Dam

Regulations) were made valid. These regulations focused very much on planning and construction of dams, but by the beginning of the 1980s the most intense hydropower development period in Norway was soon to end. NVE realized that there was a need for regulations to ensure safe operation and necessary upgrading of dams as well. In addition, there was a growing concern that the civil engineers within the hydropower sector were not replaced when they retired, and competence about dam engineering and dam safety seemed to disappear from the dam owner organizations and consulting companies. Thus, in 1992 new regulations for Supervision of Dams and other Hydraulic Structures were issued (replacing the 1982-regulations), including requirements for internal control. The most important change in this regulation was the introduction of the internal control principle.

The internal control principle did not exclude continued governmental supervision of dam safety, but the overall responsibility for the safety of the dams was very clearly placed on the dam owner. Requirements for internal control implied that the dam owner was made responsible for documenting that any legal requirement concerning dam safety was properly met. Special attention was given to the need for having adequate dam safety competence within the dam owner organization. A system of approving chartered engineers within the dam owner organizations and approving consultants within dam engineering was introduced along with a system for hazard classification of dams. During the 1990s NVE also issued guidelines for emergency planning, dam owner supervision, monitoring etc. as a supplement to the 1981-regulations, which had very few requirements for the operational phase of a dam. In 2001 three new regulations were issued with legal basis in the new Water Resources Act, replacing all the previous Norwegian regulations on dam safety and supervision of dams. The process ahead of the publication of these regulations, as well as an overview of technical guidelines to these regulations is given in [1].

Revision of the regulations from 2001

The 2001 regulations included requirements for qualifications, classification of dams and for planning, construction and operation of dams. In 2003, separate regulations on internal control were also issued. The only requirements not included in these new regulations were requirements for protection against war, sabotage and terrorist actions, which were given in separate guidelines with legal basis in the Civil Defence Act and The Energy Act. These guidelines had legal status as regulations, however.

There were, however, some difficulties in the administration of the 2001 regulations, not least because of a lack of agreement between the regulations for classification and the regulations for planning, construction and operation of dams.

Some also pointed out that the regulations were difficult to follow as the requirements were given in several separate documents. In addition the legal status for requirements concerning war, sabotage and terror was not clear to the dam owners and the consultants.

A minor revision with the aim to clarify the legal framework for dam safety was started in 2003. During the revision process, new considerations had to be accounted for, such as;

- ◆ efficiency improvement projects in NVE
- ◆ legal discussions about the safety concept
- ◆ experiences from major accidents within the transport sector in Norway
- ◆ the need for information to NVE about dam failures/accidents
- ◆ a desire for an extended classification system for dams from the insurance companies and some dam owners
- ◆ an increasing number of changes and reorganization of dam owner organizations
- ◆ a need for better coordination of the licensing process for new hydropower projects (mainly small hydro) and coherent safety evaluations (classification etc.)
- ◆ White Papers (public investigations) on societal safety influencing requirements for protection of dams against war, sabotage and terrorist actions.

The first draft for a new regulation was sent to a public hearing in 2006. The draft document included requirements for dam owner organizations, classification, planning, construction and operation of dams. The requirements for protection against war, sabotage and terror actions were slightly changed and included in the planning requirements. The classification requirements were also changed to some extent and some requirements had been moved from the underlying technical guidelines into the regulations. Coincident with the hearing process, NVE arranged seminars to inform the dam owners and other interested parties about the revision work. In 2007, requirements for qualifications of personnel within the dam owner organization, consultant companies and contractors were sent for a separate public hearing. After preparation of written submissions to the hearing, and several discussions with the Ministry of Petroleum and Energy, a final draft was sent to the Ministry for approval in 2009. The new dam safety regulation was approved by Royal decree in December 2009 and came into force on 1st of January 2010.

Contents of the new regulations

As mentioned above, a main goal in the revision process was to clarify the legal framework for dam safety, and one step in the right direction was to try assembling all requirements

related to dam safety in one regulation. Three regulations and one guideline have been replaced by one new regulation, while the regulation for internal control will be revised in the near future and continue as a separate regulation. The new dam safety regulation (the regulation for safety of dams and other hydraulic structures) contains the following chapters:

1. Objective and range of application
2. Organizational requirements
3. Qualifications
4. Classification
5. Technical plans and requirements
6. Construction and commissioning
7. Operation
8. Common requirements
9. Implementation of the regulation
10. Commencement

Most of the requirements are unchanged from the previous regulations, but there are some modifications and some new requirements.

Chapter 8, 9 and 10 include standard legal phrases common to many Norwegian regulations, such as § 8-2 (exemptions and stricter rules). These chapters will not be described further. Chapter 1 describes that the regulation is valid for all dams and all waterways, as defined in § 1-3. However, for dams and waterways in the lowest consequence class (0) only a few specific requirements are valid, for example requirements about classification (chapter 4), safety measures related to public traffic on and around dam sites (§ 7-6) and reporting of accidents (§ 7-11).

Chapter 2: Organizational requirements

Most of the requirements given in chapter 2 are unchanged and deal with how the dam owners and others involved in planning and construction of dams should be organized in order to work most efficiently with dam safety and be able to fulfill the legal requirements. For example, this chapter describes the specific responsibilities given to the chartered engineer (develop and update an internal control system for the dams and waterways, make sure that there is a safety surveillance system in place and that the safety is reassessed regularly etc.)

One of the new requirements is given in § 2-1 saying that there must be a responsible (person or organization) for every dam and waterway, and that there must be a manager, a chartered engineer and dam attendant(s). These functions can be covered by one person in case of a small dam owner organization or when the dam owner is a person, as long as this person is qualified according to chapter 3 and it is defensible with respect to safety. Another important change in chapter 2 is the introduction of regular reporting from the dam owners to NVE about dam safety responsibility and personnel, and performed surveillance (§ 2-10).

Chapter 3: Qualifications

In 2001 a separate regulation for qualifications was issued. The qualification requirements from this regulation are modified to some extent and can be found in chapter 3. As before, the chartered engineers must be qualified and approved by NVE. The requirements are related to both formal education as well as relevant experience. For example, the chartered engineers for dams in class 2 must hold a bachelor degree in civil engineering. Chartered engineers for dams in class 3 – 4 (class 4 being the highest consequence class) must hold a master degree in civil engineering. The chartered engineers in class 2 – 4 must also have minimum 30 months experience from practical safety related activities for dams and other hydraulic structures to be approved.

As before, NVE will also define specific requirements for training courses both for the chartered engineers and for other personnel in the dam owner organization. Training courses for dam safety personnel have been offered since the 1980s, and today there are three course levels:

1. Dam Safety I, a course in practical supervision of dams (required for dam attendants and chartered engineers)
2. Dam Safety II, a university level course, with exam (required for chartered engineers class 2 – 4, recommended for approved consultants)
3. Dam Safety III, an introduction course about dam safety including crisis management (for managers and chartered engineers).

The courses “Dam Safety I” and “Dam Safety III” are organized by the trade organization Energy Norway, while “Dam Safety II” is organized by the Norwegian University of Science and Technology, NTNU, see [2] and [3] for more details.

Similar requirements and system for approval as for the chartered engineers also applies to consultants working with planning and reassessments of dams, waterways and appurtenant structures. The consultants are approved for specific fields;

- I. Concrete and masonry dams
- II. Embankment dams
- III. Gates, valves, penstocks and other appurtenant structures
- IV. Flood hydrology
- V. Hydraulics for dams and spillways

The approved consultants must have a formal education in the relevant field at the M.Sc.-level (or Bachelor with long experience), and practical experience from planning and reassessments (area I, II and III), flood calculations (IV) and hydraulic calculations/physical or numerical modeling (V).

Chapter 4: Classification

Requirements for classification of dams and waterways were given in a separate regulation in 2001. Just like the qualification requirements, many of the classification requirements are also modified and there are some new requirements. The dam owner is still responsible for proposing a class for every dam or waterway (penstocks or headrace tunnels to power plants), and NVE is responsible for controlling the classification documentation and approve the class.

The classification system has been extended to 5 classes (class 0, 1, 2, 3 and 4). Class 4 and 0 are new. Class 0 is used for dams with minor failure consequences, while class 4 is the highest consequence class. In practice, many of the dams that will be reclassified and put in class 4, are the same dams that were given the most severe requirements for protection against war, sabotage and terrorist actions by the former KSFN (see above). Thus, a dam which is being reclassified and put in the new class 4 doesn't necessarily need to be upgraded. It may already meet the requirements that will be given for class 4 dams (see also chapter 5).

In addition to the new classes, NVE has also introduced limit values enabling the dam owner to put small dams and waterways directly in class 0 without further evaluation or notification to NVE;

- ◆ Dams: $h < 2$ m and reservoir volume $< 10000 \text{ m}^3$
- ◆ Penstocks: $p \times D < 0,2$, where p is static pressure [MPa] and D is diameter [m]

Dams and penstocks exceeding these physical limits can also be put in class 0, when failure consequences are limited, but then the dam owner must document the consequences as required in § 4-3 (see below).

The criteria for classification are given in § 4-2 and are very much the same as before. The limit between class 3 and class 4 is set to 150 housing units. Thus, if more than 150 housing units are affected by dam failure, the dam is put in class 4. The dam owner has to evaluate both direct consequences as well as any secondary effects from the dam break flood or flood/water jet from the ruptured penstock.

In order to be able to put the structures in the right consequence class, NVE needs relevant and updated documentation of the dam/waterway and possible consequences. Specific documentation requirements are given in § 4-3, and as a minimum the following must be included in the documentation;

- ◆ Maps and photos
- ◆ Sketches or drawings of dam/waterway with key data (including reservoir volume)
- ◆ Description of possible consequences (based on necessary calculations and evaluations)

If it is difficult to decide the total consequences NVE may

require calculations, for example a dam break flood wave calculation or other relevant calculations.

Chapter 5: Technical plans and requirements

Requirements are given for the contents of technical plans (which have to be approved by NVE prior to construction), loads (caused by natural hazards and technical failures), design, materials etc. There are specific requirements for all major dam types, spillway systems, gates, valves, penstocks and other appurtenant structures. This chapter includes very few new requirements. § 5-9 (Lowering of reservoir) is an example of a partly new requirement. However, most of this section (§ 5-9) is a continuance of requirements previously given to hydropower dams in the highest consequence classes (class 3 and 4 in the new regulation). Earlier, these requirements were given with legal basis in a regulation under the Energy Act, as opposed to the other technical requirements which were given with legal basis in the Water Resources Act.

Another example of a change is the criteria for design flood and safety check flood given in § 5-7, see Table 1, where the criteria for safety check flood in class 1 is new.

TABLE 1: DESIGN FLOOD AND SAFETY CHECK FLOOD

Class	Design flood	Safety Check Flood
4	Q1000	PMF
3	Q1000	PMF
2	Q1000	PMF or $1,5 \cdot Q1000$
1	Q500	PMF or $1,5 \cdot Q500$

Even though there are a few completely new requirements, most of the seemingly new requirements in chapter 5 have existed before 2010, but they were "hidden" in guidelines. Thus, the changes in chapter 5 have mainly been an attempt to clarify which technical requirements that are given to dams and waterways in the different consequence classes.

Chapter 6: Construction and commissioning

Chapter 6 includes requirements for relevant documentation during the construction period, such as work plan, plan for control of construction works and plan for commissioning. There are some modifications, especially in § 6-1 (construction), compared to the previous regulation, but most of the requirements given in this chapter are more or less as before.

Chapter 7: Operation

All requirements related to operation of dams are assembled in chapter 7, as opposed to the previous regulation where operational requirements were given in two different chapters. There are several new sections; § 7-7 (access obstruction), § 7-8 (securing of information), § 7-10 (special safety measures) and § 7-11 (notification of accident or undesired

event). Chapter 7 also includes, as before, requirements for operating procedures, dam surveillance, dam break flood wave calculations, emergency preparedness, reassessment, safety measures related to public traffic on and around dam sites and warning systems (in case of dam failure). Some of these requirements have been revised, and like chapter 5, some seemingly new requirements, are simply taken from guidelines. Thus, the changes in chapter 7 don't necessarily result in a need to do major updating of emergency plans etc.

Commencement of the new regulation

The dam safety regulation were approved by Royal decree in December 2009 and made valid from the 1st of January 2010. At the same time the three previous regulations from 2001 on qualifications, classification and safety and supervision of dams were repealed.

Dams that can be in a wrong consequence class due to changes in the classification criteria have been given the deadline of January 2015 for reclassification.

In addition, some new requirements will not be in force until 2011, i.e. the introduction of a new field for approved consultants (V – hydraulics for dams and spillways) and compulsory reporting of performed dam owner supervision etc (see chapter 2). The reason for this delay is that NVE needs more time to prepare approval procedures (for consultant approval) and a web-based reporting system to allow for efficient reporting. Hopefully the new reporting system will also enable automatic updating of the dam register.

As before, NVE is appointed as administrator of the regulation.

Conclusion

The Norwegian dam safety regulation from 2010, with a legal basis in the Water Resources Act, replaces three previous regulations issued in 2001, as well as requirements for dam safety which had a legal basis in The Energy Act and in the Civil Defence Act. All requirements regarding dam safety have thereby been assembled in one regulation, which hopefully contributes towards clarifying the legal framework.

Acknowledgements

The authors would like to thank Professor Indra de Soysa at the Norwegian University of Science and Technology for valuable comments on the paper, and Dag K.Lindland at The Norwegian Water Resources and Energy Directorate for data about dams.

References

- [1] Midttømme G.H. (2003). *Changes in the legal framework for dam safety in Norway*. The International Journal on Hydropower & Dams Vol. 10, Issue 5, pp. 150-152.
- [2] Lia L. (2010). *The Dam Safety engineering course – 17 years of experience and development*. Paper submitted to The ICOLD European Club Symposium, Innsbruck, Austria.
- [3] Stokseth S. (2010). *The Norwegian Dam Safety Education System*. Paper submitted to The ICOLD European Club Symposium, Innsbruck, Austria.