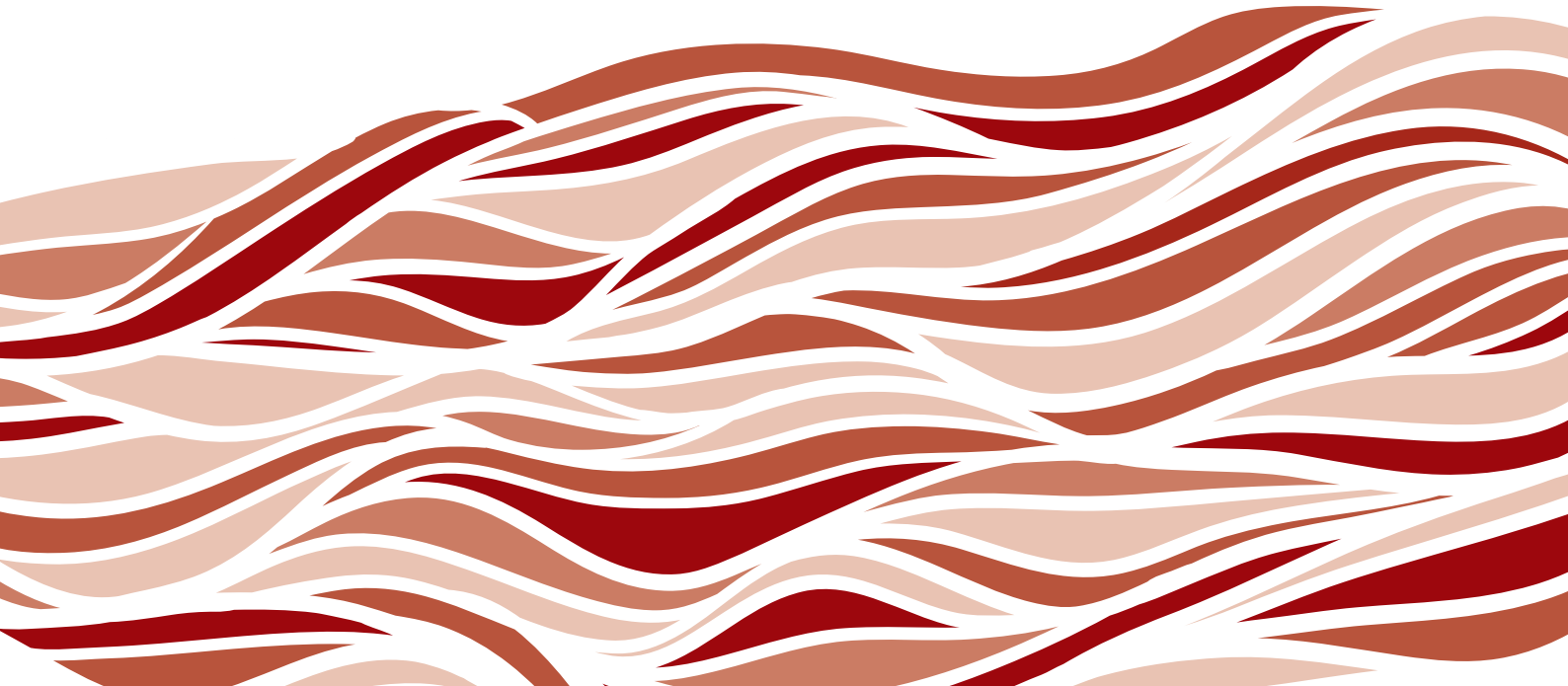
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Technical Guidelines for the
Development of Small Hydropower Plants

**UNITS**

# Part 5: Main Valves

**SHP/TG 003-5: 2019**



## DISCLAIMER

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# ACKNOWLEDGEMENTS

The technical guidelines (TGs) are the result of a collaborative effort between the United Nations Industrial Development Organization (UNIDO) and the International Network on Small Hydro Power (INSHP). About 80 international experts and 40 international agencies were involved in the document's preparation and peer review, and they provided concrete comments and suggestions to make the TGs professional and applicable.

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- The Global Network of Regional Sustainable Energy Centres (GN-SEC), particularly the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), the East African Centre for Renewable Energy and Energy Efficiency (EACREEE), the Pacific Centre for Renewable Energy and Energy Efficiency (PCREEE) and the Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE).

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Further recommendations and suggestions for application for the update would be highly welcome.

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# Foreword

The United Nations Industrial Development Organization (UNIDO) is a specialized agency under the United Nations system to promote globally inclusive and sustainable industrial development (ISID). The relevance of ISID as an integrated approach to all three pillars of sustainable development is recognized by the 2030 Agenda for Sustainable Development and the related Sustainable Development Goals (SDGs), which will frame United Nations and country efforts towards sustainable development in the next fifteen years. UNIDO's mandate for ISID covers the need to support the creation of sustainable energy systems as energy is essential to economic and social development and to improving quality of life. International concern and debate over energy have grown increasingly over the past two decades, with the issues of poverty alleviation, environmental risks and climate change now taking centre stage.

INSHP (International Network on Small Hydro Power) is an international coordinating and promoting organization for the global development of small hydropower (SHP), which is established on the basis of voluntary participation of regional, subregional and national focal points, relevant institutions, utilities and companies, and has social benefit as its major objective. INSHP aims at the promotion of global SHP development through triangle technical and economic cooperation among developing countries, developed countries and international organizations, in order to supply rural areas in developing countries with environmentally sound, affordable and adequate energy, which will lead to the increase of employment opportunities, improvement of ecological environments, poverty alleviation, improvement of local living and cultural standards and economic development.

UNIDO and INSHP have been cooperating on the World Small Hydropower Development Report since year 2010. From the reports, SHP demand and development worldwide were not matched. One of the development barriers in most countries is lack of technologies. UNIDO, in cooperation with INSHP, through global expert cooperation, and based on successful development experiences, decided to develop the SHP TGs to meet demand from Member States.

These TGs were drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of these TGs may be subject to patent rights. UNIDO and INSHP shall not be held responsible for identifying any such patent rights.

# Introduction

Small Hydropower (SHP) is increasingly recognized as an important renewable energy solution to the challenge of electrifying remote rural areas. However, while most countries in Europe, North and South America, and China have high degrees of installed capacity, the potential of SHP in many developing countries remains untapped and is hindered by a number of factors including the lack of globally agreed good practices or standards for SHP development.

These Technical Guidelines for the Development of Small Hydropower Plants (TGs) will address the current limitations of the regulations applied to technical guidelines for SHP Plants by applying the expertise and best practices that exist across the globe. It is intended for countries to utilize these agreed upon Guidelines to support their current policy, technology and ecosystems. Countries that have limited institutional and technical capacities, will be able to enhance their knowledge base in developing SHP plants, thereby attracting more investment in SHP projects, encouraging favourable policies and subsequently assisting in economic development at a national level. These TGs will be valuable for all countries, but especially allow for the sharing of experience and best practices between countries that have limited technical know-how.

The TGs can be used as the principles and basis for the planning, design, construction and management of SHP plants up to 30 MW.

- The Terms and Definitions in the TGs specify the professional technical terms and definitions commonly used for SHP Plants.

- The Design Guidelines provide guidelines for basic requirements, methodology and procedure in terms of site selection, hydrology, geology, project layout, configurations, energy calculations, hydraulics, electromechanical equipment selection, construction, project cost estimates, economic appraisal, financing, social and environmental assessments—with the ultimate goal of achieving the best design solutions.

- The Units Guidelines specify the technical requirements on SHP turbines, generators, hydro turbine governing systems, excitation systems, main valves as well as monitoring, control, protection and DC power supply systems.

- The Construction Guidelines can be used as the guiding technical documents for the construction of SHP projects.

- The Management Guidelines provide technical guidance for the management, operation and maintenance, technical renovation and project acceptance of SHP projects.

# Technical Guidelines for the Development of Small Hydropower Plants-Units
# Part 5: Main Valves

## 1 Scope

This Part of the Units Guidelines specifies the technical requirements as well as the basic requirements for the supply scope, spare parts, technical documents, inspection, testing, packing, transportation, storage, installation, commissioning, operation and maintenance for the small hydropower (SHP) turbine main valves.

This document is applicable to butterfly, spherical and gate types of SHP turbine main valves.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 780:2015, *MOD Packaging—Pictorial Marking for Handling of Goods*

IEC/TR 61364, *Nomenclature for Hydroelectric Power plant Machinery*

AWS D1.1/D1.1M:2008, *Structural Welding Code—Steel*

SHP/TG 001, *Technical guidelines for the development of small hydropower plants—Terms and definitions*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TR 61364, SHP/TG 001 and the following apply.

3.1
**nominal diameter of main valve**

inner diameter of the valve body at the connection between the main valve and the upstream/down-

stream penstock flanges; if the inner diameters on both sides are different, it refers to the smaller one, in millimetres (mm)

3.2
maximum hydrostatic pressure

hydraulic pressure developed by the water column from the horizontal centre line of the main valve to the maximum upstream water level after the main valve is closed, in MPa

3.3
maximum transient pressure

maximum pressure generated at the upstream side horizontal centre line of the main valve in the transition process of sudden closure, in MPa

3.4
design pressure

pressure for which the flow passage components of the main valve, are designed to withstand (from the strength point of view) and this shall not be less than the maximum transient pressure, in MPa

3.5
nominal pressure

digital indication of the pressure related sign specified for the convenience of the design, manufacture and use of the main valve and the relevant accessories, which is a design pressure value serialized as per the national standard, in MPa

## 4 Technical requirements

### 4.1 General requirements

**4.1.1** The main valve should be selected according to the nominal pressure, which should be greater than the design pressure.

**4.1.2** The main valve shall be designed, manufactured, inspected and tested according to the service requirement of the hydraulic turbine, and the provisions on the mechanical constructional features.

**4.1.3** The main valve shall be able to be reliably closed when the unit is subject to emergency shutdown.

4.1.4 The main valve shall be able to be closed in normal flowing water without causing harmful vibration under all the operating conditions of the unit.

4.1.5 The main valve shall be able to be opened normally when the pressure difference between both sides is not more than 30% of the maximum hydrostatic pressure.

4.1.6 The valve disc/rotor of the main valve shall have only two positions: fully opened or fully closed. The main valve shall not be partially opened to regulate the discharge.

4.1.7 The operating power supply for the main valve shall be reliable. The valve could be closed manually in an emergency when the operating power supply breaks down.

4.1.8 The main valve shall be antiseptic. The valve steel surface (except stainless steel) should be electrostatically sprayed with powder non-toxic epoxy resin, or sprayed or brushed with similar non-toxic epoxy paint with a thickness of not less than 0.3 mm after being treated with rust or sand removal to Sa2.5 through shot blasting.

## 4.2 Structure requirements

4.2.1 The main valve shall be fitted with the bypass valve or employ another structure with the same function for the opening operation under flowing water conditions. The bypass pipeline across the penstock expansion coupling shall be fitted with the expansion coupling. The nominal diameter of the bypass valve shall not be less than 10% of the nominal diameter of the main valve.

4.2.2 The mould line of the butterfly valve disc shall be designed to avoid the vibration caused by Karman vortex. The resistance coefficient of the butterfly valve shall be less than 0.15 when the valve is fully open.

4.2.3 The main valve shall be finally assembled in the manufacturer's works. After final assembly at the works and after installation in the hydropower station, the main valve shall operate smoothly, and its fully-opened and fully-closed positions shall be accurate.

4.2.4 The design of the main valve shall ensure that the following parts could be replaced without disassembling the valve:

a) Journal packings of the butterfly valve and the periphery seal of the valve disc;

b) Journal packings and the operating seal of the spherical valve (if any).

4.2.5 The gate valve used as the turbine main valve shall employ the full size structure. The structural design of the gate valve shall meet the following requirements:

a) The valve disc shall not get jammed and the valve shaft shall not get separated;

b) The materials of the seals for the valve body and the valve disc shall have hardness difference to avoid clenching;

c) The lifting height of the valve disc shall not be less than 1.1 times the gate valve diameter when the valve is opened;

d) The sealing surface of the valve disc shall have sufficient allowance and its centre shall be higher than the centre of the valve body sealing surface; when the sealing surface of the valve disc is worn, the sealing surfaces of the valve body and the valve disc shall fully coincide after the valve disc sits fully on body;

e) The gate valve shall be fitted with the adjustable mechanical opening and the closing limiters and the opening indicator for preventing the valve disc from knocking directly against the valve body.

**4.2.6** The main valves shall be fitted with expansion coupling to facilitate easy removal and installation. After being installed in the hydropower station, the seal of expansion coupling shall be leak proof.

**4.2.7** The main valve could be operated manually, electrically and hydraulically. In the hydropower station with a high automation requirement, the main valve should employ the electrical or hydraulic driving mode.

**4.2.8** The main valve shall be fitted with the following signalling devices:

a) Fully-opened and fully-closed position signal of the valve disc;

b) Locking spindle position-Main Valve Locked/Unlocked;

c) Fully-opened and fully-closed signal of the bypass valve;

d) Pressures upstream/downstream of the valve disc and the pressure difference signals;

e) Signals indicating low oil pressure and the too low oil pressure of the hydraulic system for the main valve;

f) Overhauling seal Engaged/disengaged signal devices are required for overhauling the sealing when necessary.

**4.2.9** The electric device of the main valve shall comply with the provisions on the design and operation of the electrical machines.

**4.2.10** The hydraulically-driven main valve should employ the counterweight, the high pressure air-

oil accumulator or the Nitrogen filled accumulator type hydraulic control device and shall be fitted with the mechanical or hydraulic locking device for the rotor.

4.2.11 The manually-operated main valve shall be marked with a legible arrow indicating the opening/closing direction.

4.2.12 The air release valve should be installed on the downstream side of the main valve and its nominal diameter shall not be less than 5% to 10% of the nominal diameter of the main valve. The air release valve shall be able to automatically discharge trapped air when the water is filled in the spiral casing/distributor and shall not leak water when the unit is operating.

### 4.3 Material requirements

4.3.1 The material for the main valve shall be selected according to the service conditions and the requirements in the order contract.

4.3.2 The valve body and valve disc of the butterfly valve or rotor of the spherical valve may be made by solid forging or casting, or by welding. The gate valve body should be made of cast steel. The valve journals/spindle should be made of stainless steel. The bushings should be made of cast aluminium brass or cast aluminium bronze.

4.3.3 When the connecting steel pipes in front of and behind the main valve are connected to the upstream and downstream penstocks by welding, they should be made of materials with similar properties.

4.3.4 Corresponding anti-corrosion measures shall be taken for the contact part between the valve shaft and the bearing and journal seals of the main valve, such as stainless steel or a composite material with the self-lubricating function.

4.3.5 The seals for the main valve shall be made of corrosion, cavitation and sand erosion resistant materials. With regard to the spherical valve with the dual sealing structure, the movable sealing ring and the corresponding sliding part should be made of stainless steel. The seals in contact with oils shall be made of oil resistant sealing materials.

4.3.6 The butterfly valve disc may be fitted with the metal hard seal or the non-metal soft seal. Movable seals for the operating seal and the overhauling seal of the spherical valve shall be made of stainless steel and the seal pairs shall be closely fitted.

### 4.4 Welding and the non-destructive testing requirements

4.4.1 The welding methods, procedures and welders for the parts of the main valve shall comply with the relevant provisions in AWS D1.1/D1.1M.

4.4.2 All the cast/forged/fabricated components should be stress relieved in accordance with the specified procedure before finish machining.

4.4.3 The welds shall be subjected to non-destructive tests strictly in accordance with the provisions of the drawing and technical requirements.

### 4.5 Nominal pressure series

The nominal pressure of the main valve should be selected from the following values in preference, in MPa: 0.6, 1.0, 1.6, 2.5, 4.0, 6.4, 10.0 and 16.0.

## 5 Supply scope and spare parts

5.1 The supply scope and the spare parts shall be specified by the supplier and the user in the contract document. See Appendix A for the spare parts.

5.2 The complete package of equipment of the main valve should include:

a) Main valve body as well as the operating mechanism, expansion coupling, front/rear union pipes, bypass valve and bypass pipeline, air valve, drain valve, other pipelines and sealing rings;

b) Oil pressure device or the electro-manual operating mechanism and electric control cabinet;

c) Automatic components and instruments;

d) Special tools for removal, installation and maintenance;

e) Spare parts for the quick-wear parts and additional spare parts ordered in the contract signed by and between the supplier and the user.

## 6 Technical documents

The supplier shall submit the necessary technical documents to the user, mainly including:

a) Compliance certificate and the quality inspection report;

b) On-site installation, operation and maintenance manual or operation instructions;

c) Installation arrangement, the foundation stress diagram, outside view, schematic diagram of the hydraulic operation system, electrical schematic diagram and the wiring diagram, automatic

operation system diagram and main parts drawing;

d) Delivery list.

# 7 Tests

## 7.1 Delivery tests

### 7.1.1 Requirements for the strength hydrostatic test:

a) The valve body and the upstream/downstream connecting short pipes shall be subjected to the strength hydrostatic test. The test pressure shall be at least 1.5 times the nominal pressure of the main valve and shall last for 30 min. After the test, they shall be free from any harmful permanent deformation or leakage;

b) The valve disc shall be subjected to the strength hydrostatic test. The test pressure shall be at least 1.2 times the nominal pressure of the main valve and shall last for 30 min. After the test, it shall be free from any harmful permanent deformation or leakage (except for the valve disc seal);

c) The expansion coupling of the main valve should be subjected to hydrostatic testing in the factory together with the main valve.

### 7.1.2 Requirements for the seal test:

a) With regard to the main valve designed and manufactured as per the serialized nominal pressure, the seal test pressure shall be 1.1 times the nominal pressure, the duration shall be 30 min and the leakage shall be inspected; with regard to the non-serialized valve, the seal test pressure shall be 1.1 times the design pressure, the duration shall be 30 min and the leakage shall be inspected. The journal seal and the valve body split surface shall not leak; dripping leakage or soaking leakage is acceptable on the overhauling seal and the operating seal but spraying leakage shall be rejected;

b) The expansion coupling of the main valve should be subjected to seal testing in the factory together with the main valve.

### 7.1.3 Requirements for the main valve operational test:

a) All the electric tests shall be carried out for the electric control cabinet of the main valve in the factory;

b) Opening/closing operational tests shall be carried out after the main valve is assembled. The o-

pening/closing process shall be smooth and free from any jamming phenomenon;

c) After testing, the main valve and its accessories shall be carefully inspected, and shall be free from any abnormal phenomenon like harmful permanent deformation and leakage.

7.1.4 Requirements for the main valve servomotor test:

a) After assembling, the servomotor shall be subjected to the pressure-tight test. The test pressure shall be 1.5 times the maximum oil pressure borne by the main valve operated under any working conditions and the duration shall be 30 min;

b) The servomotor piston seal shall be subjected to the corresponding leakage test. The test pressure shall be the maximum oil pressure borne by the main valve operated under any working conditions, and the duration shall be 30 min; the piston seal shall be free from any seepage or soaking leakage.

### 7.2 Site tests

7.2.1 If the valve disc and the bypass valve are operated with the oil pump when there is no water in the penstock, their operations shall be steady, and the opening/closing time shall meet the design requirements. The allowable deviation of the actual fully-opened position of the valve disc shall be $\pm 1^{\circ}$ and the minimum oil pressure value required for operation shall be recorded.

7.2.2 The main valve operated with a counterweight or pressure oil from the pressure accumulator, shall be respectively subjected to operational tests according to the design requirements when there is no water in the penstock or the water is still, and the valve closing time shall be recorded.

7.2.3 Oil, air and water pipelines welded at the site shall be subjected to the hydraulic pressure tests. The test pressure shall be 1.5 times the nominal pressure of the corresponding pipeline, and the duration shall be 30 min.

7.2.4 For the closing test in flowing water on site, the detailed test schedule shall be prepared to ensure safety. After testing, the main valve and its accessories shall be inspected in detail, and shall be free from any harmful damage.

## 8 Acceptance and guarantee

### 8.1 Inspection and acceptance

8.1.1 The main valve products as well as its main parts and the electric control cabinet shall pass the inspection by the manufacturer before being delivered, and shall be accompanied by the relevant documents proving product compliance.

8.1.2 Non-destructive test reports shall be provided for the main welds of the weldments of the main valve completed in the factory; at least the weld appearance inspection report shall be provided for the other welds.

8.1.3 The test contents specified in the order contract shall be completed in the factory and the corresponding test reports shall be provided for the main valve body, the main parts and the electric control cabinet.

### 8.2 Quality assurance/manufacturer's guarantee

8.2.1 Under the premise that the product is properly stored, installed and used, the product quality guarantee period shall be one year after the date on which the 72-hour trial operation is completed, or two years after the delivery date of the last batch of goods, or whichever comes earlier.

8.2.2 Within the quality assurance/guarantee period, the water leakage of the main valves under normal service conditions shall comply with the provisions of the order contract.

## 9 Nameplate, packing, transportation and storage

### 9.1 Nameplate

Each product shall be fitted with the product nameplate in an obvious position. Its main contents shall include:

a) Product name;

b) Supplier name;

c) Product model;

d) Nominal diameter;

e) Nominal pressure;

f) Factory number;

g) Date of production.

### 9.2 Packing

9.2.1 Before packing, the following preparation shall be made:

a) Take the necessary anti-corrosion measures for the exposed finished surface of the product;

b) Remove the fragile and vibration-sensitive components and meters, and pack them separately;

c) Fasten the movable parts in the product onto the machine body;

d) Bind the technical documents and spare parts supplied along with the product and then fasten them in the proper positions.

9.2.2 The packing, transportation and storage of the product shall comply with the relevant provisions of ISO 780.

9.2.3 The packing container shall be manufactured according to the packing drawing. The markings shall comply with the relevant provisions of ISO 780.

9.2.4 The name and quantity listed on the packing list shall be consistent with the material objects and the drawings in the container.

### 9.3 Transportation

The main valve shall be transported as a whole, if the transportation limits so allow. The transportation and the handling shall be implemented according to the marks on the packing container. The number of packages, the number of cases, markings, the delivery time and the train number shall be notified by the supplier to the user upon delivery.

### 9.4 Storage

9.4.1 The products shall be kept in the dust-free and rainproof warehouses with an ambient temperature of −5 ℃ to +40 ℃, relative humidity of not more than 85% and without acid, alkali, salt and corrosive or explosive gases and strong electromagnetic field.

9.4.2 From the date of delivery by the supplier, the supplier shall guarantee that the product is free from corrosion and accuracy reduction due to improper packing within 1 year under the normal storage conditions.

## 10 Installation and welding

10.1 General requirements for the main valve installation:

a) The installation shall be carried out on the construction site according to the design drawings and the requirements of the relevant technical documents;

b) The bearing clearance shall comply with the design requirements;

c) The jointing surfaces of the valve body shall be smooth and burr-free. The gap shall meet the following requirements:

1) The joint gap shall be inspected with a 0.05 mm feeler gauge, and the gauge shall not pass through;

2) The local gaps are acceptable and when it is inspected with a 0.10 mm feeler gauge, the depth shall not exceed 1/3 of the width of the jointing surfaces and the total length shall not exceed 20% of the perimeter;

3) There shall be no gap around the assembling bolts and pins;

d) When the main valve is installed, the centreline along the water flow direction shall be determined according to the actual centre of the spiral case and the penstock and the difference to the design location will not be greater than 3 mm; the deviation between the transverse centreline of the butterfly valve and the spherical valve (upstream and downstream positions) and the designed centreline should not exceed 10 mm; the horizontality and perpendicularity shall be measured after the flange is welded and its allowable deviation shall be 1 mm/m;

e) Sufficient clearance shall be reserved between the foundation bolt and the bolt hole of the main valve body on the opposite direction of the expansion coupling, and its value shall not be less than the thickness of the sealing material between the flanges.

10.2 Installation requirements for the butterfly valve:

a) With regard to the butterfly valve with dual seals, the clearance between the overhauling seal and the valve casing shall be uniform when the valve disc is in the closed position, and the allowable deviation shall be ±20% of the actual average clearance value;

b) If the inflatable rubber seal is used, the water seal clearance shall meet the design requirement and the allowable deviation shall be ±20% of the design clearance value when the valve disc is in the closed position and the rubber water seal is not inflated. Under the operating air pressure, the rubber water seal shall have no clearance;

c) The foundation bolts of the valve body bear all the weight of the main valve and the force and torque generated during the operation of the main valve. A clearance of 30 mm to 50 mm shall be reserved along the axial direction of the main valve in the space between the foundation bolts and the holes.

10.3 Installation requirements for the spherical valve:

a) The contact of the sealing surface of the operating seal and the overhauling seal of the spherical valve shall be tight. When inspected with the 0.05 mm feeler gauge, the gauge shall not pass through;

b) The travel and fit dimension of the seal cover shall comply with the design requirements, its actual travel should not be less than 80% of its design valve and its action shall be smooth;

c) The rotation of the valve shall be smooth, and the clearance to the fixed component shall not be less than 2 mm;

d) The maximum clearance between the seal cover and the sealing ring shall be smaller than the actual travel of the seal cover;

e) The spherical valve shall be subjected to the pressure-tight test after installation on site. Under the maximum hydrostatic pressure, the water leakage from the front and rear seals shall not exceed the design allowable value within a duration of 30 min.

10.4 Installation requirements for the gate valve:

a) Before installation, it is necessary to inspect whether the specification and model are consistent with the design; inspect whether the components of the valve are intact and whether the sealing surface is undamaged;

b) The centre deviation of the gate valve shall not be more than 3 mm and the installation of the operating mechanism shall comply with the manufacturer's and the design requirements.

10.5 Installation requirements for the expansion coupling:

a) The clearance between the inner and outer sleeves of the expansion coupling shall be adjusted to be uniform and shall not get jammed; the allowable deviation of the seal groove width shall be less than 2 mm;

b) The expansion distance between the expansion coupling and the inner/outer sleeves shall meet the design requirement, its allowable deviation shall be ±6 mm and the retraction dimension of the adjuster welding shall be considered;

c) The expansion coupling shall be connected to the main valve with flange bolts. Sealing ring shall be installed in the expansion joint and pressed with the compression ring to prevent water leakage from the expansion joint.

10.6 Installation and test requirements for the bypass valve:

After installation, the bypass valve shall be subjected to the pressure-tight test together with the bypass pipeline.

10.7 Installation requirements for the operating mechanism:

a) The installation of the oil pressure device shall meet the design requirements;

b) The installation of the servomotor operating the main valve shall meet the design requirements. In addition, the installation of the foundation plate and the base of the swing-type servomotor shall be determined according to the actual position of the connecting pin hole of the crank arm when the valve disc/rotor is in the fully-closed position; the positional deviation of the foundation plate shall not be more than 3 mm. After installation, the horizontal or vertical deviation of the servomotor shall not be more than 1 mm/m, the allowable deviation of the base elevation shall be ±1.5 mm and the connection of the pin shaft shall be flexible.

10.8 On-site welding requirements for the main valves:

a) With regard to the expansion coupling and the connection pipeline welded to the turbine casing and the penstock on site, the welding deformation shall be prevented in the welding process so as to ensure the perpendicularity of the flange surface and the coaxiality to the centreline of the main valve;

b) The clearance around the expansion coupling shall be uniform. After welding, the expansion distance of the expansion coupling shall be inspected; its deviation should not exceed ±15% of the design expansion valve.

## 11 Operation and maintenance

11.1 Before filling water into the water diversion system/forebay of the hydropower station for the first time, the sundry materials in the water diversion system shall be cleaned thoroughly to prevent such sundry materials from damaging the main valves.

11.2 To prevent damage to the main valve caused by water filling, slow filling with light flow should be carried out for high water head power stations and the long penstock power stations. In the water filling process, the situation of the main valve shall be closely inspected; in the event of any abnormal situation, the water filling shall be immediately stopped for inspection and treatment. The water filling test could not be continued until all the problems are solved.

11.3 The operation and the daily maintenance of the main valve shall be carried out according to relevant technical documents and the automatic operation procedures. The main equipment and acces-

sories of the main valve shall be periodically maintained.

11.4 For the main valve equipped with the manual mechanical locking device, check whether the manual mechanical locking device has been put into operation before you overhaul the unit. Check whether the manual mechanical locking device is withdrawn before the main valve is turned on after the overhaul is complete.

11.5 For the power stations with much sediment and harsh operating conditions, attention should be paid to the main valve maintenance and repair.

# Appendix A
（Normative）
# Spare parts for the main valves

Table A.1 Spare parts for the main valves

Unit：Set

| No. | Name of the spare parts | Quantity | | Remarks |
|---|---|---|---|---|
| | | 1-2 units | 3 units or more | |
| 1 | O-ring of various specifications | 1 | 2 | |
| 2 | Journal packing of the valve disc | 1 | 2 | |
| 3 | Circumferential seals of the valve disc | 1 | 2 | Only limited to the butterfly valve |
| 4 | Seals on the movable sealing ring | 1 | 2 | |
| 5 | Piston seal of the servomotor | 1 | 2 | |
| 6 | Piston rod seal of the servomotor | 1 | 2 | |
| 7 | Seal of expansion coupling | 1 | 2 | |
| 8 | Fixed sealing ring and movable sealing ring | 1 | 1 | |
| 9 | Split key or pin | 1 | 1 | |
| 10 | Shaft sleeve of the various specifications | 1 | 2 | |
| 11 | Bearing bushings of various specifications | 1 | 2 | At valve shaft |
| 12 | Springs of various specifications | 1 | 2 | |
| 13 | Travel switch | 1 | 2 | |