



DPC: 24 / 30457087 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 29 February 2024

Origin: International

Latest date for receipt of comments: 17 April 2024

Project No. 2022/01278

Responsible committee: MCE/15 Hydraulic turbines

Interested committees:

Title: BS EN IEC 61116 Electromechanical equipment guide for small hydroelectric installations

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

**WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD.
THIS DRAFT IS NOT CURRENT BEYOND 17 April 2024**

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <http://standardsdevelopment.bsigroup.com>

Responsible Committee Secretary: **Committee Service Centre (BSI)**
Direct tel: **020 8996 7009**
E-mail: csc@bsigroup.com

 **Documents**
Document Sharing Hub

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
------------------	------------------------

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

PROJECT NUMBER:

IEC 61116 ED2

DATE OF CIRCULATION:

2024-02-23

CLOSING DATE FOR COMMENTS:

2024-05-17

SUPERSEDES DOCUMENTS:

4/439/RR

IEC TC 4 : HYDRAULIC TURBINES

SECRETARIAT:

Canada

SECRETARY:

Mrs Christine Geraghty

OF INTEREST TO THE FOLLOWING COMMITTEES:

PROPOSED HORIZONTAL STANDARD:

☐

Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC☐ ENVIRONMENT☒ QUALITY ASSURANCE☐ SAFETY

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

TITLE:

Electromechanical equipment guide for small hydroelectric installations

NOTE FROM TC/SC OFFICERS:

Copyright © 2024 International Electrotechnical Commission, IEC. All rights reserved. It is permitted to download this electronic file, to make a copy and to print out the content for the sole purpose of preparing National Committee positions. You may not copy or "mirror" the file or printed version of the document, or any part of it, for any other purpose without permission in writing from IEC.

CONTENTS

FOREWORD	5
1 Scope	7
2 Normative references	8
3 Terms, definitions, symbols and units	8
3.1 General	8
3.2 General terminology	8
3.3 Units	11
4 Methodology	11
5 Description of installation and operating conditions of power station	11
5.1 Site conditions	11
5.2 Hydraulic conditions for plant and design criteria for the units	12
5.3 Electrical conditions for plant operation	13
5.3.1 The plant is intended to operate in isolated grid	13
5.3.2 The plant is intended to operate in parallel with a grid which imposes the frequency	14
5.3.3 Energy transport and distribution	14
5.4 Types of regulation and modes of operation	14
5.4.1 Frequency regulation	14
5.4.2 Power regulation	15
5.4.3 Level control	15
5.4.4 Flow regulation	15
5.4.5 Simplified governing	15
5.5 Automation, telemetry, remote control, alarms	15
6 Equipment specifications	15
6.1 Technical requirements	16
6.2 Limits of the supply	16
6.2.1 For the hydraulic system	16
6.2.2 For the electric system	16
6.2.3 For the auxiliary system	16
6.2.4 Elements not normally included in the supply	16
6.3 Specifications of the elements of the plant	16
6.3.1 Trashrack and rack cleaner	16
6.3.2 Water-level control	17
6.3.3 Discharge closure devices (see Figure 6)	17
6.3.4 Penstock	18
6.3.5 Turbine (see Figure 7)	18
6.3.6 Generator	22
6.3.7 Automatic control system	24
6.3.8 Main transformers (reference can be made to IEC 60076)	25
6.3.9 Auxiliary equipment	25
6.3.10 Spare parts and special tools	26
6.3.11 Mechanical handling	27
6.3.12 Corrosion protection	27
6.4 Guarantees	27

6.4.1	General	27
6.4.2	Discharge closure devices	28
6.4.3	Turbine	28
6.4.4	Generator	29
6.4.5	Governor	29
6.4.6	Speed increaser	29
6.4.7	Excitation equipment	29
6.4.8	Comments concerning the complete generating set	30
6.4.9	Main transformer	30
6.5	General conditions for tender enquiries and comparison of tenders	30
6.5.1	Instructions to tenderers	30
6.5.2	General conditions of contract	30
6.5.3	Technical comparison of tenders	30
7	Inspection, delivery, operation and maintenance	31
7.1	Approval of the design and inspection of the work	31
7.1.1	Approval of design documents	31
7.1.2	Inspection of materials and sub-assemblies	31
7.1.3	Inspection at manufacturer's works	32
7.1.4	Delivery	32
7.1.5	Assembly at site	32
7.2	Commissioning	33
7.2.1	Preliminary checks before watering-up	33
7.2.2	Watering-up	34
7.2.3	Unit rotation	34
7.2.4	Preliminary checks and electrical load tests	34
7.3	Operation	35
7.3.1	Probationary period	35
7.3.2	Guarantee period	35
7.3.3	Normal operation	37
7.4	Training of personnel	37
7.5	Checking and maintenance	38
	Bibliography	53
	Figure 1 – Example of sequence of events	42
	Figure 2 – Flow duration curve (showing river flow and plant flow)	43
	Figure 3a – Run-of-river power station	44
	Figure 3b – Run of plant in a bypass channel	44
	Figure 4a – High and medium head plant arrangement	45
	Figure 4b – Low head station (bulb unit and rim generator unit)	46
	Figure 4c – Low head station (vertical unit and unit with elbowed tail-race)	47
	Figure 4d – Low head station (siphon unit and unit with elbowed penstock)	48
	Figure 5a – Single line diagram - Asynchronous generator	49
	Figure 5b – Single line diagram - Synchronous generator	50
	Figure 6 - Hydraulic closure devices (examples)	51
	Figure 7 - Schematic representation of a hydraulic machine	52

Table 1 - Examples of checks during normal operation	40
Table 2 - Elements of bid evaluation	40

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTROMECHANICAL EQUIPMENT GUIDANCE FOR
SMALL HYDROELECTRIC INSTALLATIONS**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 61116 has been prepared by IEC technical committee 4: Hydraulic turbines. It is an International Standard.

This second edition cancels and replaces the first edition published in 1992. This edition constitutes a technical revision.

This edition has been subject to a thorough review and incorporates many comments received at the various revision stages.

The text of this International Standard is based on the following documents:

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

ELECTROMECHANICAL EQUIPMENT GUIDANCE FOR SMALL HYDROELECTRIC INSTALLATIONS

1 Scope

This International Standard is used as a guidance that applies to hydroelectric installations containing impulse or reaction turbines with unit power up to about 15 MW and reference diameter of about 3 m. These figures do not represent absolute limits.

This standard deals only with the direct relations between the purchaser or the consulting engineer and the supplier. It does not deal with civil works, administrative conditions or commercial conditions.

This standard is intended to be used by all concerned in the installation of electromechanical equipment for small hydroelectric plants.

This standard, based essentially on practical information, aims specifically at supplying the purchaser of the equipment with information which will assist him with the following:

- preparation of the call for tenders;
- evaluation of the tenders;
- contact with the supplier during the design and manufacture of equipment;
- quality control during the manufacture and shop-testing;
- follow-up of site erection;
- commissioning;
- acceptance tests;
- operation and maintenance.

The standard comprises the following:

- a) general requirements for the electromechanical equipment of small hydroelectric installations;
- b) technical specifications for the electromechanical equipment, excluding its dimensioning and standardization;
- c) requirements for acceptance, operation and maintenance.

Bearing in mind the type of installation considered, the necessary documents are intended to be as simple as possible but to satisfactorily define the particular operation conditions. Over-specification is harmful to the economy of the project.

This standard does not cover the initial stage of investigations, that is to say the preliminary study and feasibility study. Neither does it deal with the economic study concerning the supply and demand of energy.

To conclude, the standard does not replace the necessary engineering studies for the selection, design, manufacture, installation and testing of the equipment. It is intended only to make the purchaser aware of the important points and data to be furnished, specified and kept in due consideration in the construction of small hydroelectric plants.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, symbols and units

3.1 General

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org>

3.2 General terminology

3.2.1

power station

An installation whose purpose is to generate electricity and which includes civil engineering works, energy conversion equipment and all the necessary ancillary equipment.

[SOURCE: IEC 60050-602:1983, 602-01-01]

3.2.2

hydroelectric installation

An ordered arrangement of civil engineering structures, machinery and plant designed chiefly to convert the gravitational potential energy of water into electricity.

[SOURCE: IEC 60050-602:1983, 602-01-03]

3.2.3

hydroelectric power station

A power station in which the gravitational energy of water is converted into electricity.

[SOURCE: IEC 60050-602:1983, 602-01-04]

3.2.4

run-of-river power station

A hydroelectric power station which uses the river flow as it occurs, the filling period of its own reservoir by the cumulative water flows being practically negligible.

[SOURCE: IEC 60050-602:1983, 602-01-05]

3.2.5

reservoir power station

A hydroelectric power station in which the filling period of the reservoir based on the cumulative water flows is longer than several weeks.

Note 1 to entry: A reservoir power station generally permits the cumulative water flows to be stored during the high water periods to enable the turbine to operate during later high load periods.

[SOURCE: IEC 60050-602:1983, 602-01-07]

3.2.6

gross head of a hydroelectric power station

The difference in height between the water intake and tail-race levels under specified conditions.

[SOURCE: IEC 60050-602:1983, 602-01-11]

3.2.7

net head of a hydroelectric power station

The gross head of a hydroelectric power station less a height equivalent to the hydraulic losses excluding those in the turbines.

[SOURCE: IEC 60050-602:1983, 602-01-12]

3.2.8

generating set

A group of rotating machines transforming mechanical or thermal energy into electricity.

[SOURCE: IEC 60050-602:1983, 602-02-01]

3.2.9

hydroelectric set

A generating set consisting of a hydraulic turbine mechanically connected to an electrical generator.

[SOURCE: IEC 60050-602:1983, 602-02-03]

3.2.10

dam

A structure to retain water inflows for specific uses.

[SOURCE: IEC 60050-602:1983, 602-02-05]

3.2.11

penstock

A pipeline bringing water under pressure to the turbine.

[SOURCE: IEC 60050-602:1983, 602-02-09]

3.2.12

surge tank; surge shaft

An open-surface reservoir of water decreasing the effects of shock pressure waves in the penstock.

[SOURCE: IEC 60050-602:1983, 602-02-10]

3.2.13

impulse type turbine

A turbine in which a fluid acts chiefly by its kinetic energy.

[SOURCE: IEC 60050-602:1983, 602-02-11]

3.2.14

reaction type turbine

A turbine in which a fluid acts both by its kinetic energy and by its pressure.

[SOURCE: IEC 60050-602:1983, 602-02-12]

3.2.15

Pelton turbine

A hydraulic impulse type turbine usually operated from a high head source with small flow rate.

[SOURCE: IEC 60050-602:1983, 602-02-13]

3.2.16

Francis turbine

A hydraulic reaction type turbine with fixed runner blades usually operated from a medium or low head source with medium flow rate.

[SOURCE: IEC 60050-602:1983, 602-02-14]

3.2.17

Kaplan turbine

An axial hydraulic reaction type turbine with adjustable runner blades operated with a high flow rate.

[SOURCE: IEC 60050-602:1983, 602-02-15]

3.2.18

bulb-type unit

A hydroelectric set with its casing containing the generator and turbine immersed in the water flow.

[SOURCE: IEC 60050-602:1983, 602-02-16]

3.2.19

propeller turbine

A Kaplan type turbine with non-adjustable runner blades suitable for non-varying head sources.

[SOURCE: IEC 60050-602:1983, 602-02-17]

3.2.20

unit generator transformer set transformer

A transformer connected to the generator terminals through which output power of the generator set is transmitted to the system.

[SOURCE: IEC 60050-602:1983, 602-02-31]

3.2.21

auxiliary transformer of a unit [of a powerstation]

A transformer supplying auxiliaries of a unit [of a power station].

[SOURCE: IEC 60050-602:1983, 602-02-32(33)]

3.2.22

gross output of a set

The electrical power produced at the terminals of the main and auxiliary generators of the set.

[SOURCE: IEC 60050-602:1983, 602-03-04]

3.2.23

gross output of a power station

The electrical power produced at the terminals of the main and auxiliary generators of a power station.

[SOURCE: IEC 60050-602:1983, 602-03-05]

3.2.24

net output of a set

The gross output less the power consumed by the associated auxiliaries.

[SOURCE: IEC 60050-602:1983, 602-03-06]

3.2.25

net output of a power station

The gross output less the power consumed by the associated auxiliaries and less the losses in the associated transformers.

[SOURCE: IEC 60050-602:1983, 602-03-07]

3.2.26

power demand from the system

The power which has to be supplied to the system in order to meet the demand.

[SOURCE: IEC 60050-602:1983, 602-03-13]

3.3 Units

The International System of Units (SI, see ISO 80000-4) has been used throughout this document.

All terms are given in SI Base Units or derived coherent units (for example N instead of kg.m.s⁻²). The basic equations are valid using these Units. This has to be taken into account if other than coherent SI-Units are used for certain data (for example: kilowatt or megawatt instead of watt for power, kilopascal or bar instead of pascal for pressure, min⁻¹ instead of s⁻¹ for rotational speed, etc.). Temperatures may be given in degrees Celsius because thermodynamic (absolute) temperatures (in Kelvins) are rarely required.

Any other system of units may be used, but only if agreed to in writing by the contracting parties.

4 Methodology

In the interests of clarity, the sequence of the necessary steps for the construction of a small hydroelectric power plant is represented diagrammatically in Figure 1.

It principally covers the preparation of technical specifications, the examination of tenders, the manufacture, and finally the commercial operation and maintenance of equipment.

This sequence also shows the relationship between the different phases and areas of responsibility of all the parties concerned (consulting engineer, chief resident engineer, and users).

If the purchaser does not have in-house engineering capabilities or the services of a consulting engineer he may call for, to facilitate relations with contractors, a "turn-key" supply, or have at least a leading contractor responsible for the supply of all or part of the electromechanical equipment (e.g. the turbine/generator package, or a "water-to-wire" package).

5 Description of installation and operating conditions of power station

The following data is generally required by the equipment supplier and should appear in the enquiry. In some cases, all these data are not always readily available. Nevertheless, it must be emphasized that the more information that is given the better will the project be understood and therefore the better the technical solution which will result.

5.1 Site conditions

5.1.1 Supply a topographic survey (plan and profile) giving the altitude of the points indicated and the position desired for the main works (see Figure 4), water intake, reservoir, channel, surge tank or head pond, penstock, power plant, headwater, tailwater and their main characteristics (sections, lengths, materials of the channels and penstocks, etc.). Indicate the foundation conditions (sand, rock, soft ground, etc.).

5.1.2 Attach numbered pictures with cross-references to the topographic survey described in 2.1.1, showing the setting and location of the main works.

5.1.3 Supply the chemical analysis of the water with extremes of temperature and, if necessary, the amount and size of sediments carried by the water in the area around the water intake or downstream of the sand trap, if any.

209 Indicate the presence of any living organisms or floating debris, etc.

210 **5.1.4** Specify the local conditions; extremes of air temperature, humidity, occurrence of
211 strong winds, earthquakes, etc.

212 **5.1.5** Indicate any transport or access limitations.

213 **5.1.6** Certain information mentioned in 6.1.5.1 and 6.1.5.3 (erection) may also be shown
214 in the tender enquiry if this reflects a particular feature of the purchaser's own country.

215 **5.1.7** State if it is run-of-river (see Figure 3) or a scheme with a reservoir.

216 Indicate if there exist any particular operational constraints: e.g. multi-purpose scheme,
217 environmental, fisheries, etc.

218 State and describe (with drawings) those elements of the plant which are part of an existing
219 installation which it is foreseen will eventually be put back into use.

220 **5.1.8** State if the plant will be manned or unmanned.

221 **5.2 Hydraulic conditions for plant and design criteria for the units**

222 **5.2.1** Specify the maximum allowable up or down surges in the channels.

223 **5.2.2** Provide a flow duration curve (see Figure 2) with an indication of the limiting flows
224 (guaranteed water supply, irrigation, drinking-water).

225 **5.2.3** Specify the chosen design flow, Q_a , in cubic metres per second, and the availability
226 in days per year.

227 **5.2.4** Specify the extreme water-levels at the intake and at the tail-race in metres (m)
228 above sea-level, as follows.

229 a) headwater level max ... m

230 min ... m

231 b) tailwater level max ... m

232 min ... m

233 c) operational range allowed: ... m

234 and give the curves for:

235 d) level versus discharge (headwater and tailwater)

236 e) level versus volume of the headwater reservoir or head pond (essential for a reservoir
237 scheme).

238 **5.2.5** Specify the desired outputs and the duration of the corresponding operations.
239 The net heads are defined as in IEC 62006. The crossflow turbines with diffusers being
240 considered as reaction turbines.

241 **5.2.6** State the number of units suggested.

242 **5.2.7** Define the evaluation criteria for efficiency over the full range of operation as well
243 as overload conditions (weighting the efficiency according to the amount of energy produced
244 at different heads and flows). The weight to be given to a particular efficiency or overload
245 depends on the time of utilization at the point of operation considered and the energy thus
246 recovered from the installation. For general instructions to tenderers see clause 6.5.

247 NOTES

248 1 For low head plants with short intakes, care must be taken in the design of the intake in order to obviate
249 hydraulic problems such as vortices and air admission.

250 2 The proper design of the waterways is essential in order to minimize the head losses (difference between gross
251 and net head).

252 **5.2.8** For containerized mini hydroelectric plants, the influence of container storage space
253 on the type and size of the hydroelectric units should also be considered.

254 **5.3 Electrical conditions for plant operation**

255 The plant electrical conditions and requirements listed under either 5.3.1 or 5.3.2.

256 **5.3.1** The plant is intended to operate in isolated grid

257 a) Without any other energy supply on the grid

258 For isolated grids, black-start capability is essential.

- | | | |
|-----|---|-------------------|
| 259 | i) Required grid voltage | V |
| 260 | Tolerance (under steady-state conditions) | + ... % - ...% |
| 261 | ii) Grid frequency | Hz |
| 262 | Tolerance (under steady-state conditions) | + ... % - ... % |
| 263 | iii) Minimum output required all year round by the grid | kW |
| 264 | iv) Load acceptance rate of the grid (to determine | |
| 265 | whether or not a flywheel is required) | kW/s |
| 266 | v) Hydraulic inertia time constant (T_w) | s |
| 267 | vi) Mechanical inertia time constant (T_a) | s |
| 268 | vii) Value of the maximum step-change in load which the | |
| 269 | grid can accept | + ... kW - ... kW |
| 270 | viii) Power factor ($\cos \varphi$) | |

271 b) With permanent connection to another electrical energy supply defined as follows:

- | | | |
|-----|---|--------------------------|
| 272 | i) Hydroelectric unit: | type |
| 273 | | min output ... kW |
| 274 | ii) Thermoelectric unit: | type |
| 275 | iii) Generator characteristics (synchronous or asynchronous): | |
| 276 | • rated voltage | V |
| 277 | • rated frequency | Hz |
| 278 | • rated output | kVA |
| 279 | • inertia J of rotating parts | kg· m ² |
| 280 | • Mechanical inertia time constant (T_a) | s |
| 281 | • power factor ($\cos \varphi$) | |

282 iv) Turbine governor characteristics

283 The grid conditions are to be defined as in 5.3.1 a), items ii) to vii).

284 v) Voltage regulator characteristics (distribution of reactive power).

285 The grid conditions are to be defined as in 5.3.1 a), items i) and viii).

286 d) Energy utilization: daily and seasonal load variations

Output (kW)	minimum	average	maximum
Passive loads (lighting, heating, drying, ...)			
Active loads (electric motors)			
Total			

287

288 In order to decide the method of regulation and the design of the governor, it is necessary to
 289 give an indication of the load variations (load curve):

- 290 a) daily;
 291 b) weekly;
 292 c) seasonal.

293 Indicate the priority and non-priority loads (load shedding) as this is useful for designing the
 294 governor.

295 **5.3.2** The plant is intended to operate in parallel with a grid which imposes the frequency

296 a) Characteristics of the grid

- 297 i) Voltage V
 298 Tolerance + ... % - ... %
 299 ii) Frequency Hz
 300 Tolerance + ... % - ... %
 301 iii) Short-circuit power (at the point where the
 302 new scheme is linked to the grid) kVA
 303 iv) Power factor ($\cos \varphi$)

304 b) Apparent output of the largest generator working
 305 on the grid kVA

306 **5.3.3** Energy transport and distribution

307 Provide the following drawings:

- 308 • a general layout drawing of the entire proposed grid, in the case of isolated load operation;
 309 • a drawing showing the link to the grid, in the case of operation in parallel with a large grid.

310 The layout should also indicate the main load centres and power supply points.

311 Also provide information on any possible developments of the grid.

312 **5.4 Types of regulation and modes of operation**

313 **5.4.1** Frequency regulation

314 If the unit or the plant operates in an isolated grid, or is an important part of the grid, a governor
 315 is required to maintain the grid frequency during load changes.

For units with low output and where hydraulic energy is abundant, simplified governors could also be used by producing a constant output at full load and dumping the unused power.

5.4.2 Power regulation

The operating position of the power station in the power system map and the accuracy requirement of power regulation should be clarified.

The type of power regulation should be specified, and the load regulation curve according to the plan should be provided when taking part in peak load or intermediate load of the system.

5.4.3 Level control

Specify if it is necessary to maintain the headwater or tailwater level constant, or within a working range using the generating sets or some other discharge device. If this is so, the turbine opening must then be governed with level feedback. This is generally the case with run-of-river plants (in the river itself or in a bypass channel) or when linked to an irrigation canal.

NOTE On isolated load, level or frequency may be controlled but not both.

5.4.4 Flow regulation

Specify the presence of reservoirs or not, the types of regulation employed, and the regulation capacity.

NOTE On isolated load, flow or frequency may be controlled but not both.

5.4.5 Simplified governing

If the plant is to operate on a large grid which imposes the frequency, its units can be fitted with simplified governors (positioners) having level feedback or load feedback. Stability may be affected in the case where part of a large grid becomes accidentally detached and simplified governors are used.

5.5 Automation, telemetry, remote control, alarms

a) Indicate if staff are available for the starting and shut-down sequences or if it is required to minimize the use of operators.

b) If the plant is unattended, unmanned or remote controlled, specify where the alarms are to be located.

c) Specify whether the starting sequence, synchronization, loading and shut-down operations shall be:

i) manual;

ii) and/or automatic;

iii) and/or remote controlled (in this case, indicate the location of the control centre, the carrier and the type and method of transmission of the signals).

d) Where a scheme has a reservoir, and there are several units, specify if manual or automatic control of the reservoir water is required (operation according to a programme).

e) Specify if the plant is to be the control centre for other energy supply sources in the grid.

6 Equipment specifications

The information given below is useful in establishing technical specifications and comparing the technical offers for the most important items in a small hydroelectric development.