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**Hydrometry — Hydrometric data  
transmission systems — Specification of  
system requirements**

*Hydrométrie — Systèmes de transmission des données  
hydrométriques — Spécification des exigences des systèmes*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

- an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;
- an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 24155 was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 5, *Instruments, equipment and data management*.

## Introduction

Hydrometric data transmission systems provide data for the day-to-day management of water resources and for warning and forecasting of floods, droughts and conditions affecting water quality and public health. The systems transmit data measured at remote telemetry stations to a receiving center for further processing.

This Technical Specification defines and standardizes the required specifications of hydrometric data transmission systems. It does not describe the specifications of the equipment and units constituting hydrometric data transmission systems, but does describe the functional performance that the hydrometric data transmission systems should provide.

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# Hydrometry — Hydrometric data transmission systems — Specification of system requirements

## 1 Scope

This Technical Specification specifies the technical requirements that should be considered in designing and operating hydrometric data transmission systems and the necessary functions of those systems.

## 2 Normative references

The following referenced documents are indispensable for the application 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 772:1996, *Hydrometric determinations — Vocabulary and symbols*

ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units*

ISO/IEC 2382-1:1993, *Information technology — Vocabulary — Part 1: Fundamental terms*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 772 and ISO/IEC 2382-1 apply.

## 4 Basic requirements

### 4.1 General

This clause specifies the general requirements for designing a hydrometric data transmission system (HDTS).

An HDTS shall be designed to meet the basic requirements, defined hereinafter, taking into consideration functionality, geographical structures, time structures, installation conditions, reliability, safety, maintainability and economy. The final system specifications should be determined through the process of repetitive discussions among technological specialists in hydrological and telecommunications fields.

The conceptual configuration of an HDTS is shown in Annex A.

### 4.2 Objectives of use

An HDTS shall be designed with a full understanding of the necessity and importance of hydrometric services for appropriate water management in river basins in which this system is to be used.

### 4.3 Functional requirements

The functional requirements for an HDTS are classified into the following.

- a) **Mandatory requirements:** the minimum requirements that an HDTS designer shall comply with in designing the system. The mandatory requirements include legal requirements, for example for the site where the system will be installed, and applicable specifications of various standards.
- b) **Optional requirements:** the functions and methods of implementing them that an HDTS designer can select. The optional requirements include the requirements, such as the data collection sequence and selection of communications link as specified in Clause 5.

An HDTS should be designed to fully achieve the mandatory functional requirements, and to meet the optional requirements in full consideration of the user's requirements and operational purposes of the system so as to demonstrate the required system functionality.

### 4.4 Geographical structures

The following geographical structures shall be determined as a fundamental element of HDTS:

- a) location(s) of the remote telemetry station(s);
- b) location(s) of the receiving center(s); and
- c) location(s) of the relay station(s), if necessary.

A remote telemetry station is located at a selected hydrometric-observation point. Therefore, remote telemetry stations are distributed over a geographically wide area, including a river basin. Remote telemetry stations can not always be located at optimum hydrological sites, but may be relocated from the planned sites because of geographical problems and difficulties in data transmission.

A receiving center consists of equipment and receives data from remote telemetry stations for data processing and display; it is located at a site where data and/or information is needed. Therefore, the receiving center will usually be located within the facility of a user organization. In large river basins, receiving centers may be distributed at user organizations near a hydrometric-observation point.

According to the necessity of the communication medium, a relay station shall be provided in the system.

These geographical structures should be considered not only at the time of designing but also for the future plans.

### 4.5 Time structures

Usually, an HDTS is used on a real-time basis. An HDTS has two time domains: the first domain is the time used in the natural world; the other is the time series in system operation.

The basic property of time in system operation is the time when the hydrometric observation is made at a gauging point; the gauging intervals and the delay times are required in data presentation.

Usually, sensors at remote telemetry stations continuously measure hydrological phenomena, but the data monitored at the receiving center are sampled in a time series. Therefore, these time characteristics and their allowable error range should be determined for the purposes of operation. Details are shown in Annex E.

## 4.6 Installation conditions

The environmental conditions of the remote telemetry stations may be more severe than those of telecommunication equipment installed indoors. Therefore, the following conditions should be considered:

- a) temperature range and rate of change;
- b) relative humidity range with no condensation;
- c) wind velocity;
- d) seismic resistance;
- e) damage due to sea wind, dust, and/or toxic gases;
- f) available power supply conditions (including impact of surge currents due to lightning);
- g) equipment damage and access during flooding.

The environmental conditions of the telecommunications and information equipment to be installed at a receiving center should also be considered for items a), b), d) and f) above. Details are shown in Annex C.

## 4.7 Considerations for designing

### 4.7.1 Reliability

An HDTS is basically designed for continuous operation for its original purpose of use, particularly in the case of heavy rains and floods. Designers shall consider the reliability of equipment and the entire system. For the important functions of the system, alternative means or a redundancy of the system should be provided.

For example, duplicate communication lines can be installed to connect important remote telemetry stations in a gauging area to a receiving center. A hot-standby system can also be used for the equipment having important functions. The hydrological data measured by important remote telemetry stations can be input to site recorder and the storage term(s) and period should meet the user's requirements.

### 4.7.2 Safety

An HDTS shall be designed as a safe (fail-safe) system that can always secure safe system operation in the case of a malfunction of equipment, faulty operation by a user, or a system failure due to any external factor. The fail-safe should prevent such problems from spreading over the entire system.

If the malfunction or failure in part of the system or faulty operation by a user is non-critical, the principal functions of the system should continuously operate because of the importance of hydrometric observation.

### 4.7.3 Data permanence

The permanence of hydrometric data should be assured, since these are stored and used for water resources management over a long period.

The permanence of the data shall be assured even if peripheral unit(s) are replaced. In addition, interface specifications shall be defined for the data transmission system, format and transfer timing between the sensors to be installed in the pre-stage of an HDTS and the information processing system to be installed in the post-stage of an HDTS. Data received at the receiving center should be saved on reliable media.

#### 4.7.4 Maintainability

The HDTS equipment shall be designed to have a composition that is easy to maintain and repair.

The HDTS equipment should be designed so that it is easy to check and replace parts, and so that inspections and adjustments can be conducted (easily or) conveniently.

Software shall be designed with future maintainability taken into consideration, i.e. for future modifications and/or future improvements. Documentation shall be provided in order to easily carry out necessary procedures for the cases when modifications are required.

#### 4.7.5 Operability

Each piece of the equipment shall be designed to allow for simple operation and to avoid erroneous operation, such as authority limits and wrong operation refuse. An HDTS should be designed to enable the receiving center to supervise the operational status of the entire system, identify problems and control necessary operations.

#### 4.7.6 Economy

An HDTS should be designed to have a good cost performance in terms of required functions and reliability. The economy of the system should be evaluated considering the entire life cycle cost including the initial cost and operational cost. An HDTS should allow future updating or expansion.

## 5 Functional requirements of system

### 5.1 General

The functional block diagram of an HDTS is shown in Annex B. The hydrometric data measured at remote telemetry stations are encoded into a format adequate for transmission at the remote telemetry stations. Communications are made between the remote telemetry stations and the receiving center according to a prescribed collection sequence, transmitting the encoded data from the remote telemetry stations to the receiving center. The receiving center decodes the received data and performs data verification and processing to disseminate it to users as hydrometric information. An information processing system may be provided in the stage following this system.

### 5.2 Remote telemetry stations

#### 5.2.1 General

The principal function of a remote telemetry station is to measure hydrometric data using sensors. This is a process for collecting data to be input to the system and for monitoring hydrological phenomena that change with time.

#### 5.2.2 Locations

The locations of remote telemetry stations shall be determined in considering the distances from the receiving center and the topography of the sites of the stations. The possibility of using the sites, the availability of existing communication lines and radio links, the radio propagation conditions (if radio links are chosen), the lead-in conditions from power sources and the access roads should also be considered as important factors for determining the locations. The items that should be investigated in selecting the sites of remote telemetry stations from the viewpoint of data transmissions are shown in Annex C.

### 5.2.3 Data measurements

The measuring conditions for data to be acquired shall be specified based on operational purposes.

The items to be specified are

- a) data type and number of measuring points,
- b) range of measurement, effective digits and measuring accuracy and resolution,
- c) timing of measurement,
- d) input interface (typical interfaces are shown in Annex D),
- e) threshold values for detecting alarms, and
- f) other necessary items.

Specifications of sensors and converters are outside the scope of this Technical Specification. However, the SI Units (International System of Units) specified in ISO 1000 shall be used for measurement.

### 5.2.4 Data processing

In general, the results of data measurements should be transmitted as momentary data without being processed. However, such input data may be processed for conversion into a form that can be transmitted at the interfaces with the sensors. For some data and under certain measuring conditions, it may be effective to calculate the moving average; maximum and minimum values of the data measured at successive time points at remote telemetry stations and transmit the calculated results. Judgement, marking and deletion of abnormal data should be considered.

In recording and displaying the data measured at remote telemetry stations, the following items should be considered and decided:

- a) storage of multiple data for batch transmission;
- b) protection against data loss due to system troubles;
- c) securing the convenience for system maintenance.

## 5.3 Telemetry system

### 5.3.1 General

The telemetry system is the core of this HDTs, and its principal function is to transmit the data measured by sensors at remote telemetry stations to the data processing system at the receiving center.

### 5.3.2 Amount and intervals of data transmission

The total amount of data and intervals of data transmission shall be provided for each data transmission link. The necessary capacity (speed) of a communication line is determined by adding the allowable transmission delay time to these parameters and also depends on the selected data communication channel.

### 5.3.3 Data collection sequence

The data collection sequence that is the fundamental function of the telemetry system shall be determined. There are various data collection and transmission sequences, such as continuous data transmission with time, data transmission in certain intervals, and data transmission when the data reaches certain threshold values.

The method in which the receiving center polls the remote telemetry stations one after another and receives the data measured at each polling time may cause time differences in measurement as restricted by the polling order. On the other hand, the method in which remote telemetry stations measure data at regular times, temporarily record the data and transmit the data to the receiving center asynchronously with the measurements can minimize the delay time in measurements.

The typical methods are shown in Annex E.

#### 5.3.4 Communication lines

There are various types of communication links and communication methods such as wired lines, radio links, public telecommunication lines, mobile telephone network and satellite communication links. The type of communication link and communication method shall be decided by taking into consideration the communication environment and conditions of use including the amount of information to be transmitted, transmission speed, reliability of transmission, operating environment, feasibility and economy, and allowable delay time.

The communication lines available for data transmission and their technical outlines are shown in Annex F. Communication lines should be decided through comprehensive evaluation of the following items:

- a) types and functions of communication lines that are provided by the telecommunication company in the area where HDTS is to be installed;
- b) possibility (including technical and legal restrictions) of constructing dedicated communication lines for the telemetry system other than those provided by telecommunication company;
- c) required transmission speed calculated from the amount of data that the telemetry system transmits (amount of data transmissions), sampling intervals and allowable delay time;
- d) required reliability and economy of communication lines. Reliability should be considered in event of disasters and floods, and economy should be considered for the initial cost and life cycle cost.

Usually, exclusive radio communication links are used. In such cases, the frequencies and output powers are provided by international standards and national laws. Radio communications are usually available over distances of several tens of kilometres. Relay stations may be needed for longer distances and/or steep terrain. Since the quality of radio communication depends on the peripheral conditions, propagation tests should be made after designing the communication links. A general process of designing simplex radio links is shown in Annex G.

#### 5.3.5 Network architecture

Networks for interconnecting remote telemetry stations and receiving centers may be configured as various architectures depending on the locations of the remote telemetry stations and the receiving centers, the types of communication lines to be used, presence of relay stations, etc. Appropriate network architecture shall be determined with a full understanding of the advantages and disadvantages of various architectures, such as economy, reliability and adaptability. Some network architectures for the telemetry system are shown in Annex H. Data repeating methods at a relay station are shown in Annex I.

### 5.4 Receiving center

#### 5.4.1 General

The principal functions of the receiving center are data collection through telemetry, data verification and processing, and dissemination of the results to users. The process of data processing and the subsequent process may be conducted by providing a separate information processing system. In such a case, the details are outside the scope of this Technical Specification.

#### 5.4.2 Data verification

Data shall be verified to ensure the quality of collected data.

The data verification can be classified into two processes.

- The first is to detect errors in data transmission. This can be performed using parity bit, Cyclic Redundancy Check (CRC) error detection codes or other methods. These methods may be included in the communication control procedure.
- The other process is to examine the properties of hydrometric data, which can be performed using measured range of sensors, the upper and lower limits of data values, and limits of changing rate of measured data. Since most of the threshold values of these items vary depending on types of systems and/or application forms, the system should be designed to enable threshold values to be set as parameters that can be specified individually. These data verification processes may be handled in the data processing system.

The system will generate a report that identifies potentially spurious data.

#### 5.4.3 Data processing

Data processing in the HDTS is the process that generates meaningful hydrological information from the data measured at remote telemetry stations.

Users generally make their decisions based on operational information instead of basic hydrometric data. Therefore, necessary conversion functions should be incorporated in the real-time environment if the system is not provided with an information processing system in the post-stage of the HDTS.

Parameters for processing, such as the stage-discharge relation, may be modified afterwards. Therefore, the real-time information that is necessary for decision-making and the information that is stored as hydrometric records for a long time should be separated within the HDTS.

#### 5.4.4 Data storage

The HDTS shall have a function to store data and information in a memory media on the system.

The data storage in the HDTS should be intended for

- buffering measured data until it is transmitted to an information processing system after the HDTS,
- real-time generation of information by combining data at multiple time points, and
- temporary storage of real-time information necessary for decision-making.

Information that will be stored for a long time and used as standards should be stored as a database in an separate information-processing system from the HDTS.

#### 5.4.5 Data display and printing

The system shall have the functions of displaying and printing out data and information in tables and graphs. For these functions, there are methods for displaying and printing data immediately after each timing of data collection, and methods for outputting a batch of data collected at multiple sampling times (such as daily) and for outputting information on a timing as requested by a user.

## 5.5 System supervision

### 5.5.1 General

An HDTs shall be able to record its operational status, to provide a report of this record in order to check its operational status and to quickly notify users of problems, so that users can identify and remove the causes of problems, and quickly and appropriately restore the system.

### 5.5.2 Supervision of operational status

The system should always be supervised to promptly detect any problems.

The remote telemetry stations are to be installed geographically distributed and operated unmanned. Therefore, the operational status of the entire system including the remote telemetry stations should be supervised, and any problems should be detected remotely from the receiving center.

The remote telemetry stations should be designed to report the status of telemetry equipment, sensors and power supplies to the receiving center. The receiving center should check the contents of status reports from remote telemetry stations inspect for any equipment malfunctions in the receiving center and provide notification of potential problems.

### 5.5.3 Alarming

The contents of status reports and the affected ranges shall be defined to record and report the extent of malfunctions and related problems. The necessity of troubleshooting should be ranked into two levels.

- “Warning” is used for an alarm that needs a countermeasure.
- “Caution” is used for an alarm that signals a warning level and/or a temporary problem that can automatically be recovered.

## 5.6 Power supply

Power supply shall be designed with thorough consideration for stable operation of the system. Especially, the power supply to remote telemetry stations shall be carefully designed because external power supply may not be available or stable depending on the installation environment. Typical concepts of power supply are given below.

- a) During ordinary times, an external power supply such as a commercial power line is used to run the system. In the case of external power failure, batteries and other backup power sources are used. The systems that need a high power capacity and important systems may be equipped with generators. The guaranteed backup hours should be determined based on the importance of the system (usually, several hours to several days).
- b) Instead of using an external power supply, photovoltaic and/or wind power generation is used. Backup batteries should also be used if there is a possibility that there may be periods during which power cannot be generated because the photovoltaic or wind power supply is affected by weather conditions. The guaranteed backup duration should be determined based on the prevailing weather conditions at the area where the system will be installed and the importance of the system (usually, one week to a month).

Details are given in Annex J.

The scale of backup power supply is determined by the electric power required at the load side and the guaranteed backup duration. The load electric power should be calculated by investigating the necessity of a backup power supply for each equipment and screening the equipment that really needs backup. The guaranteed duration should be calculated by considering weather conditions, such as annual sunshine hours and wind conditions, the voltage and frequency fluctuation ranges of commercial power sources, estimated frequency of power failures, and other possible external factors as well as the importance and economy of the equipment.

## 6 Operational requirement

### 6.1 General

For stable operation of the HDTS, specialists in hydrology and telecommunications technology should prepare various manuals and standards concerning the management of the system, including its operation and maintenance.

### 6.2 Operating and maintenance manual

The data management system should be determined for the whole system, including methods for long-term data storage and for recovery of data loss as well as ordinary operations. Methods for maintaining the system, hardware countermeasures against data errors and system failures, and methods for keeping and handling consumables and spare parts in stock should also be determined.

### 6.3 Maintenance

For stable data acquisition over a long period, the system should have a preventive maintenance schedule.

Preventive maintenance consists of daily inspection, periodical inspection and exchange of parts. Daily inspection is to check whether the entire system is normally operating by referring to the printouts from the printer or displays at the receiving center. Periodical inspection consists of checking the system through visual checks and using testing instruments for preventive maintenance; inspection items differ depending on the inspection periods. If there are parts that have predefined life cycles, these parts are changed during periodical inspections.

Remote telemetry stations are usually operated unmanned. It is difficult to inspect such remote telemetry stations at their sites on a daily basis; these stations should be subject to periodical inspection. The intervals of periodical inspection (and the parts changed) vary depending on the equipment to be installed and the climatic conditions at the sites, but are usually several months, or are before and after the flood season.

## Annex A (informative)

### Configuration of hydrometric data transmission systems

Figure A.1 shows the concept of HDTS configuration.

The HDTS is configured by remote telemetry stations and a receiving center. The remote telemetry stations are installed at hydrometric points and the receiving center is installed at a point needing hydrometric data and information.

A remote telemetry station basically consists of telemetry equipment and communications equipment, to which power is supplied from power supply equipment. The telemetry equipment is connected to sensors to measure hydrometric data and it communicates with the receiving center in accordance with a preset data acquisition sequence. The communications equipment is available in types corresponding to line types and provides communication functions between the telemetry equipment and the monitoring equipment at the receiving center.

The remote telemetry stations are connected to the receiving station via communication lines, which are radio links in many cases, but may be wired lines. If radio links are used, relay stations are deployed as needed.

The receiving station basically consists of communications equipment and monitoring equipment to which an operating console and a printer are installed as peripheral equipment. The operating console is used for various operations to the monitoring equipment and may display data. The monitoring equipment collects the hydrometric data from remote telemetry stations in a preset collection sequence and performs data processing, on-line storage, data display and printing and recording. An information processing system may be installed in the stage after this system, but this system is out of the scope of the HDTS.

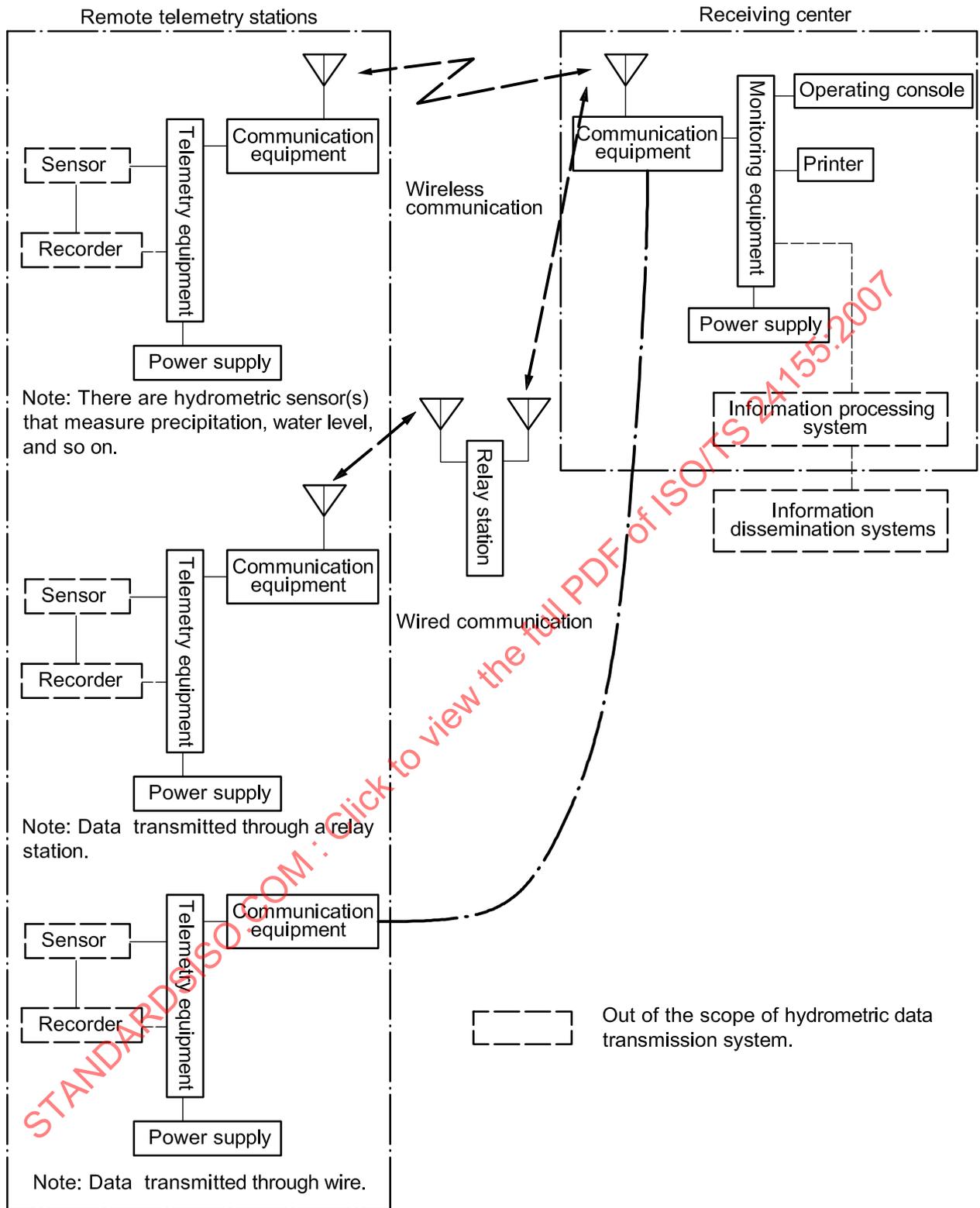


Figure A.1 — Configuration of hydrometric data transmission systems

## Annex B (informative)

### Functional block diagram of hydrometric data transmission systems

Figure B.1 shows the functional block diagram of HDTS. The equipment configuration corresponding to that shown in Annex A is indicated on both sides of the figure.

A remote telemetry station measures the data via interfaces with sensors and encodes the data in accordance with control logic, and communicates with the sensors on a collection sequence under communication control. If the remote telemetry station is required for data display, storage and processing, the control logic performs it.

The encoded data from each remote telemetry station is transmitted via a communication interface on a communication link to the receiving center.

The receiving center performs communications on a collection sequence under communication control and collects the data from remote telemetry stations via communication interface. The system control is the core function of HDTS, which performs centralized control of the system operations such as collection sequence. The received data is decoded and verified. Then, the data is displayed, stored or further processed.

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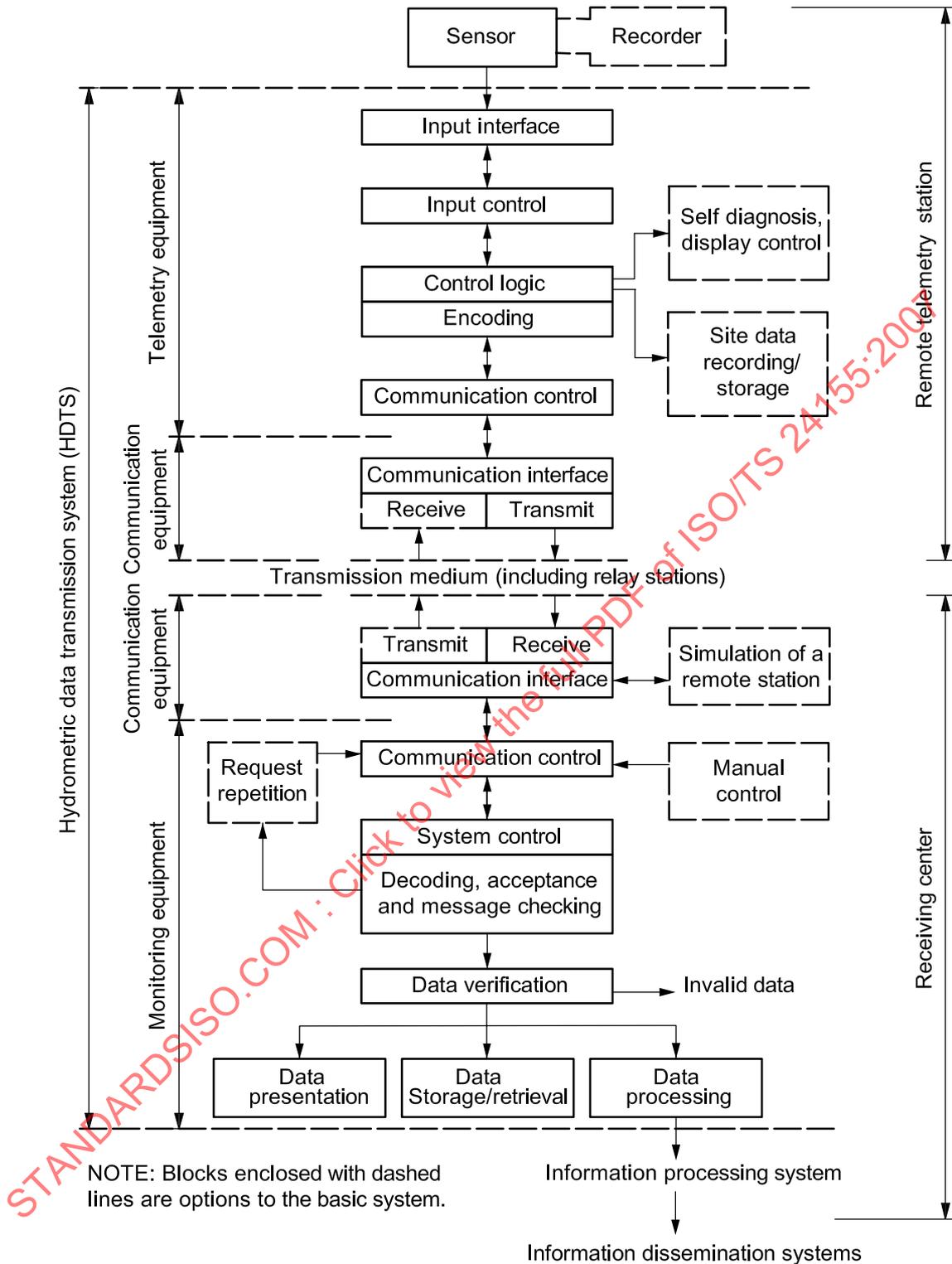


Figure B.1 — Functional block diagram of hydrometric data transmission systems

## Annex C (informative)

### Locations of remote telemetry stations

#### C.1 Conditions for selecting locations of remote telemetry stations

Examples of the conditions for selecting the locations of remote telemetry stations are given below.

- The land area shall be sufficiently large.
- It shall be possible to obtain the permission of the landowner to use the land or to purchase the land.
- The weather conditions shall not be very different from those of the surrounding areas.
- The sites shall be safe against floods, landslides, etc.
- If solar batteries are used, the annual average sunshine duration shall be sufficient and the conditions of obstacles, such as trees, buildings and mountains, shall not be fatal to solar batteries.
- If wind power generation is used, a sufficient wind velocity shall be available throughout a year.
- The access to the sites shall be easily available for installation and maintenance.
- If there are possible noise sources (such as factories, high-voltage transmission lines, heavy traffic road sections) near the sites, they shall not affect data transmissions.
- There shall be no adverse effects of vibrations, dusts, toxic gases, etc.
- The routes for transporting equipment shall be available.
- The sites shall be appropriate for the layout and installation of the equipment in terms of the dimensions and weight, and selected after investigation of those factors.
- The frequency of lightning should be known so that adequate countermeasures can be taken.

#### C.2 Locations for installing radio communications equipment

Examples of the conditions for selecting the locations for installing the radio communications equipment when very high frequency (VHF)/ultra high frequency (UHF) radio communication links are used are given below.

- The degree of interference from the said radio station or from other radio stations shall be low enough for communications.
- If two or more antennas are installed within very close quarters in a same site, the degree of mutual interference should be sufficiently low. If there is mutual interference, the degree of interference should be minimized by separating the antennas, inserting filters, etc.
- Radio communication stations for point-to-point communication should be located at elevations as low as possible through comprehensive evaluation of the radio paths, communication links, terrain profiles, and conditions of the locations, and should never be located at high points, such as the tops of mountains except for relay station.

- The equipment composition and radio link design should be appropriate in terms of frequency, transmission method, radio paths and terrain profiles.
- It shall be possible to set an antenna post having a height that is estimated from the results of radio propagation tests.

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## Annex D (informative)

### Interfaces of hydrometric sensors at remote telemetry stations

The interfaces between hydrometric sensors and data transmission systems (telemetry equipment) should be determined through comprehensive consideration of the properties of measured data, detection methods of sensors, distances between the sensors and the data transmission system, costs, affinity with the data transmission system, and universality.

Usually, sensors are determined first, because of using existing sensors or the limited types of sensor that are physically restricted by the hydrometric data to be measured and the observation sites. In such cases, interfaces are chosen from the available interfaces for the sensors in considering the above factors.

General and typical interfaces are

- Analogue: 0-1V, 1-5V, 4-20 mA, etc.,
- Digital: bit parallel input such as Binary Coded Decimal (BCD), Gray code, etc.,
- Pulse: AC pulse, no-voltage contact pulse, etc.,
- Serial: RS-232, RS-422, RS-485, SDI-12, HART, etc.

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## Annex E (informative)

### Data collection sequence

#### E.1 General

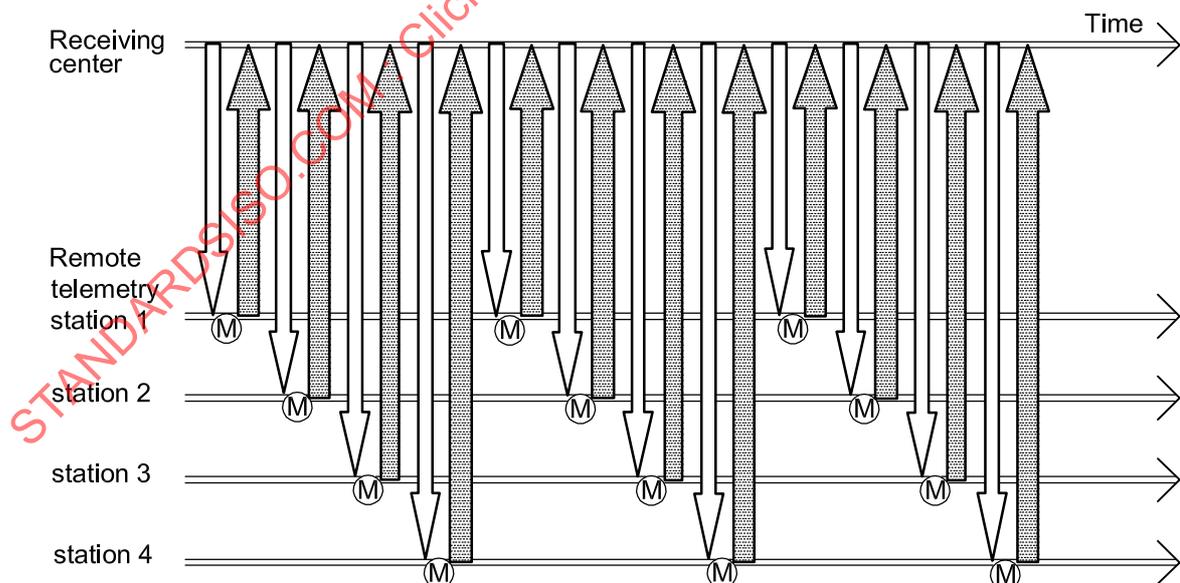
Typical data collection and transmission sequences are shown in this annex. There are three (3) categories of working modes of HTDS: interrogation, self-reporting, and a combination of interrogation and self-reporting. The interrogation mode includes E.2, E.3 and E.4. The self-reporting mode includes E.5, E.6 and E.7. In the combination mode, a system normally operates in the interrogation mode; it operates under both modes when a threshold value is exceeded or upon the demand of the receiving center.

It also is advisable for remote telemetry stations to have the capability for field operators to enter supplemental data such as field-measured parameters (for example, suspended sediment concentration).

#### E.2 Cyclic polling

Cyclic polling is used on the condition that various remote telemetry stations can jointly use a single communication line. Remote telemetry stations are polled one after another, and after polling of the last remote telemetry station, the first station is polled again, making a cyclic polling.

In general, the entire system should be polled at intervals based on the highest demand standard, but the system may be divided into several groups by the degree of demand for intervals, each of which is cyclically polled independently.



#### Key

(M) measuring

Figure E.1 — Cyclic polling

### E.3 On-demand polling

On-demand polling is a cyclic polling, from the first to the last remote telemetry stations, that is made at a minimum necessary timing interval, such as every hour. This method is appropriate for systems that use communication lines based on communication time-dependent charging. It is also effective for those remote telemetry stations that need to minimize power consumption, such as those that use solar batteries.

The method has the disadvantage that the measuring timing differs among remote telemetry stations if the measurement at each station takes a long time, or if there are many remote telemetry stations to be polled.

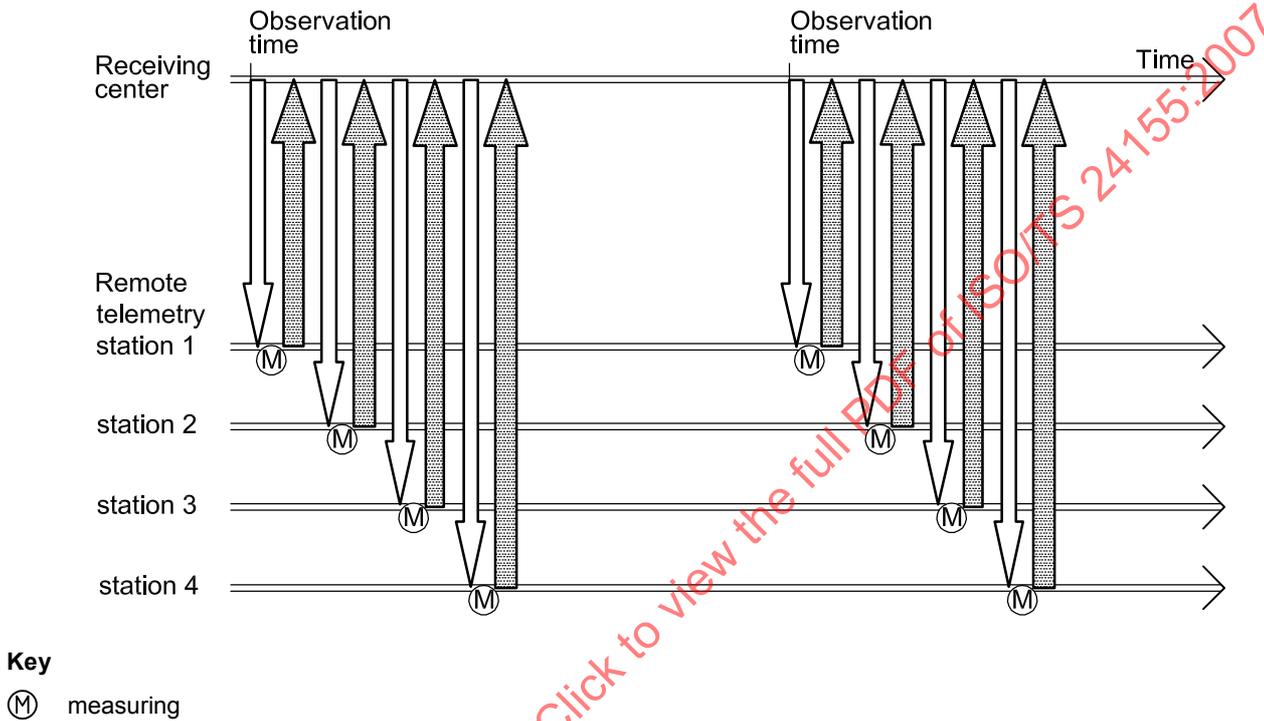


Figure E.2 — On-demand polling

## E.4 Batch polling and sequential reporting

Batch polling and sequential reporting is an improved method that combines E.3 and E.6. The sequence is shown below.

- The receiving center polls all remote telemetry stations at each time of measurement.
- Each remote telemetry station conducts measurement when it is polled, and stores the data in its local memory.
- Each remote telemetry station transmits the measured data to the receiving center after a specified waiting time ( $W_n$ ). The  $W_n$  should be specified as a different time constant for each station to prevent jamming.

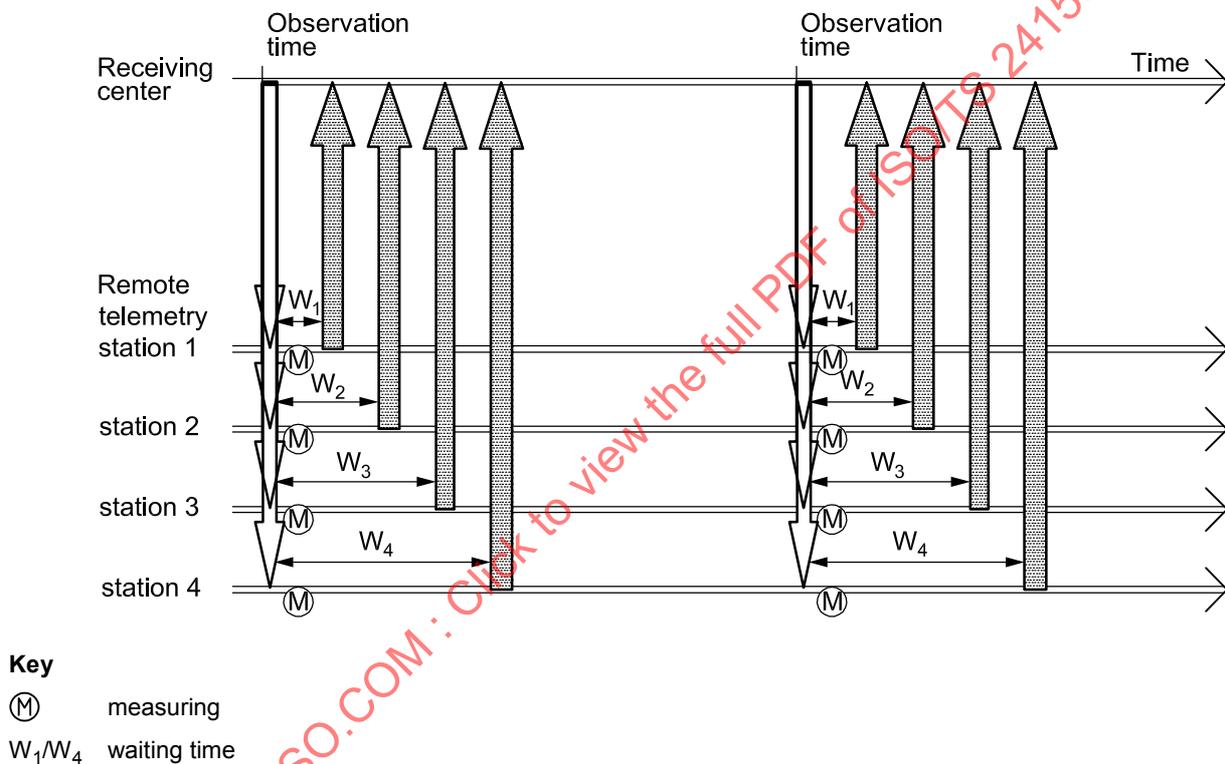


Figure E.3 — Batch polling and sequential reporting

On-demand polling (E.3) has the disadvantage that it has different measuring timing among remote telemetry stations. The batch reporting method (E.6) needs a highly precise clock at each station. On the other hand, this method (E.4) conducts measurements at all the stations at the times when the receiving center makes synchronous polling to all the remote telemetry stations. Therefore, the measuring timing is the same at all stations, and there is no need of a precise clock at each station.

### E.5 Continuous transmission

Continuous transmission is used on the condition that a remote telemetry station can make exclusive use of a communication line between the station and the receiving center. This method allows the remote telemetry station to continuously and sequentially transmit the measured data to the receiving center. The receiving center can arbitrarily sample data at necessary intervals and has a high degree of freedom.

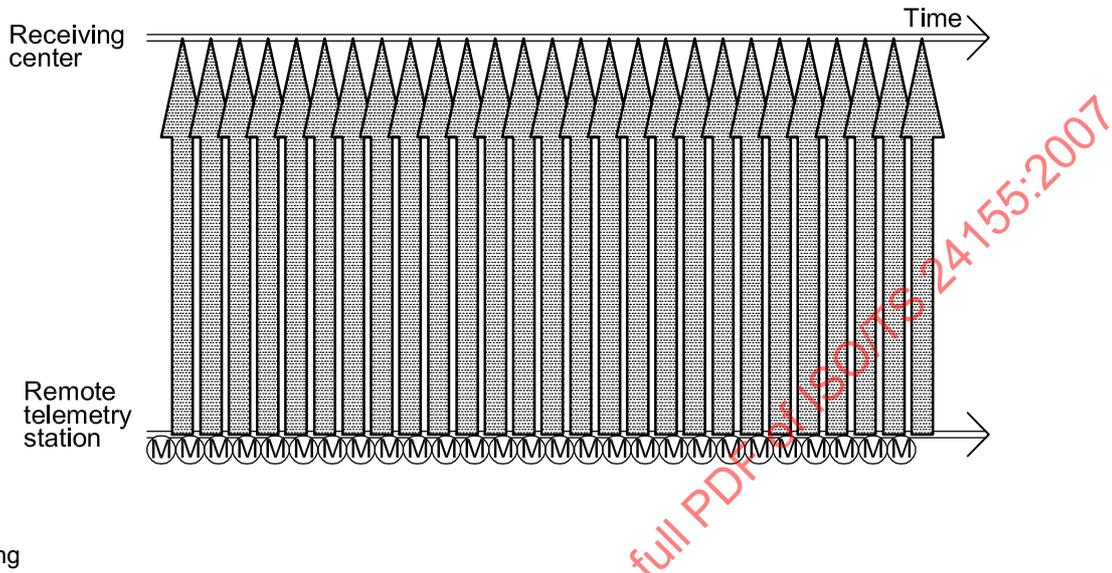


Figure E.4 — Continuous transmission

## E.6 Batch report

A batch report is a method by which the data for a certain period of time (several sampling data sets) are stored at a remote telemetry station to transmit a batch of data to the receiving center as the result of polling, or by the automatic reporting function of the remote telemetry station.

This method is effective for the telemetry systems that cannot make communications during certain hours, such as via polar-orbit satellites.

Since the method conducts measurements independently at each remote telemetry station, a highly precise clock is needed at each station to conduct punctual measurements. Each station should also be equipped with a device to temporarily store the measured data.

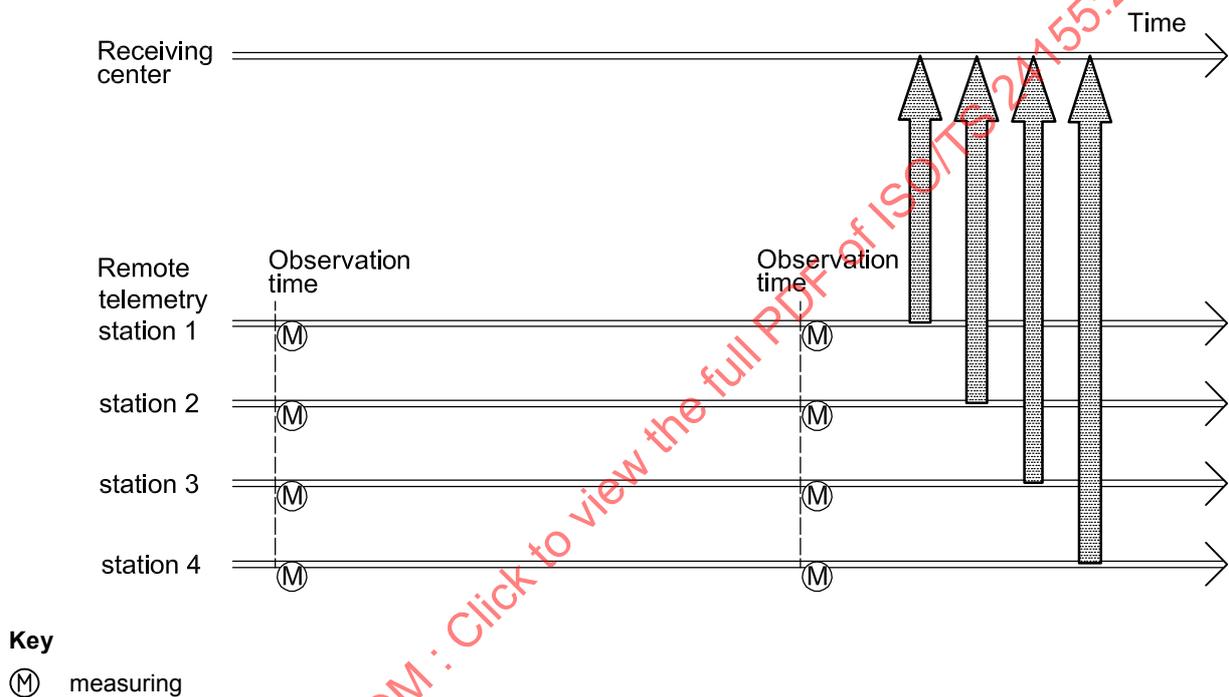


Figure E.5 — Batch report

### E.7 Event reporting

In event reporting, remote telemetry stations automatically transmit data to the receiving center in the event that a sensor detects a precipitation value or a water level value exceeding the preset upper (or lower) limit. This method is effective for the receiving center to immediately detect events. The method can also be used to collect periodical data by processing the data at the receiving center at certain intervals.

When data are not transmitted to the receiving center for a long time, it is difficult to identify whether there is no event or whether there is a system problem. Therefore, this method should be combined with the method of automatically transmitting data at scheduled times in order to configure a reliable telemetry system.

If a large number of remote telemetry stations jointly use a communication line, transmissions from various remote telemetry stations may overlap, resulting in data losses depending upon the number of remote telemetry stations and the frequency of events. Therefore, measures against data convergence (such as repetitive transmission of a data set and transmission of integrated data) are needed to improve reliability.

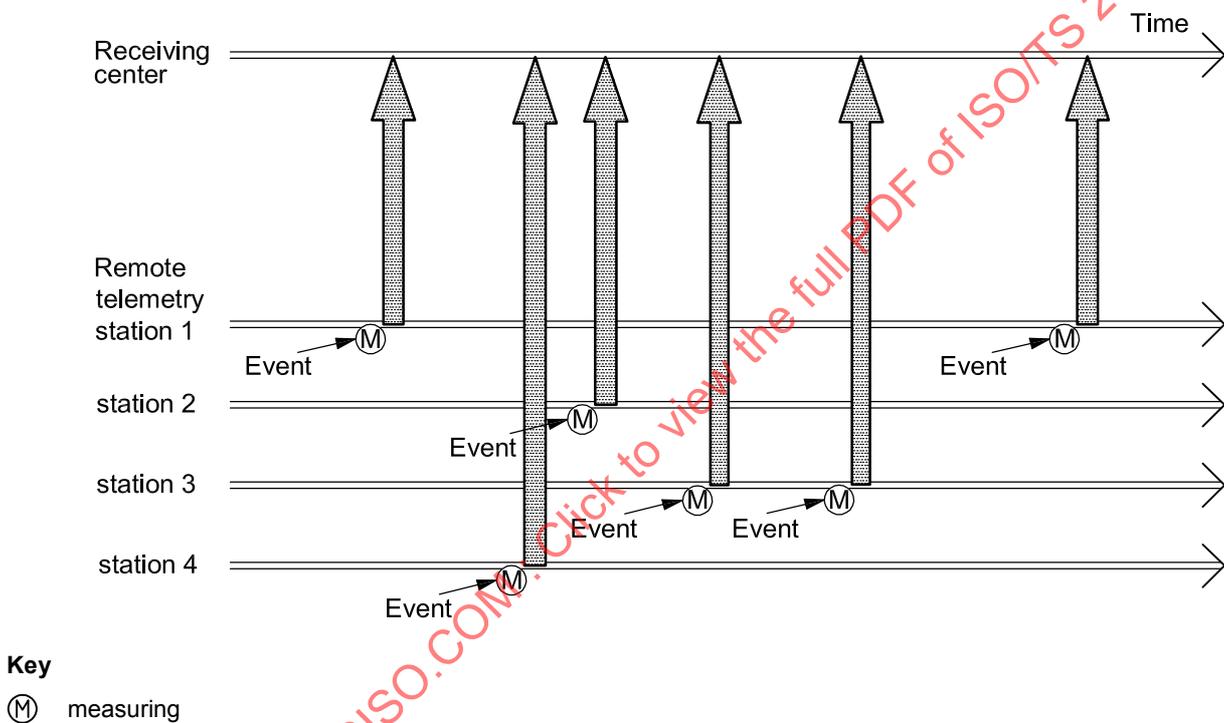


Figure E.6 — Event reporting

## Annex F (informative)

### Communication lines for data transmission

#### F.1 General

Communication media and technologies that are available for telemetry systems are outlined in this annex. Telemetry systems should meet the standards of the communication medium.

#### F.2 Telephone lines

Telephone lines provide a switched telephone network with dial pulse or multi-frequency signalling.

The cost is usually communication time-dependent, though in some areas, such as within a city, the cost is fixed.

There are analogue and digital lines. Usually, their transmission performances are conforming to international or domestic standards, and the communication quality is guaranteed.

The transmission speed on an analogue line using communication modems is over 50 kbps (kilo bits per second) if the line has a good quality.

The transmission speed on a digital line using communication modems is usually over 100 kbps.

The traffic on the lines may drastically increase in the event of disaster, and it may be impossible to use the line due to convergence.

#### F.3 Mobile phone lines

Mobile phone lines provide a switched mobile telephone network with multi-frequency signalling.

The cost for voice traffic is usually dependent on communication time. For data communication, the cost may not be dependent on the communication time, but on the amount of data (number of packets). There are cases of fixed cost but with limitation to data communications.

There are analogue and digital systems. Usually, their transmission performances conform to international or domestic standards, and the communication quality is guaranteed.

The analogue system is classified as the first generation, and is usually inappropriate for data communications.

The digital system of the second generation allows data communications at 9 600 bps (bits per second) or more. The 2.5th and third generations of mobile communication allow high-speed data communications at several hundreds of kbps.

Besides mobile phone services that use wireless base stations on land, there are mobile phone services that use satellites.

These mobile phone services use a switching system, including those in the packet cost or fixed cost system. The traffic on the lines may drastically increase in the event of disaster, and it may be impossible to use the line due to convergence.

The communication also can adopt Short Message Service in Mobile phone lines. Short Message Service is a words/characters transmission and receiving business between point to point or Short Message Entity to Short Message Entity and message center covers message information storage and re-transmission.

#### F.4 Common carrier leased lines

Common carrier leased lines provide dedicated line service to a specific user or group of users.

The cost is usually fixed.

There are analogue and digital lines. Usually, their transmission performances conform to international or domestic standards, and the communication quality is guaranteed.

The transmission speed on an analogue line using communication modems is over 50 kbps if the line has a good quality.

The transmission speed on a digital line is 50 kbps or over depending on the class of service, and there are high-speed services at several to several hundreds of Mbps (mega bits per second).

Since the line is for exclusive use, there is no convergence by increase in traffic.

#### F.5 Internet connection

A constantly connected high-speed line service is available for exclusive use of data communication through the Internet.

Depending on the transmission routes to be used, there are optical fibre cables, Digital Subscriber Line (DSL) and Cable Television (CATV).

The lines are constantly connected and the cost is usually fixed.

The available communication protocol is limited to Internet Protocol (IP).

In the Internet, the quality of service is on a best-effort basis. There is a possibility of convergence when the traffic increases.

#### F.6 Privately-owned lines

The lines are installed and operated by users themselves. The initial investment is necessary, but there is no cost during operation.

There are various transmission media, such as copper twisted pair cables, coaxial cables and optical fibre cables.

There are various types of line terminal equipment available from simple communication modems to multiplex terminal equipment.

It is possible to select a wide range of communication speeds from several tens of bps (bits per second) to several Gbps (giga bits per second) by combining the above communication media and line terminal equipment.

The communication quality on private links should be checked by the users themselves.

## F.7 VHF/UHF radio communication links

The effective use of frequencies is available worldwide under the control of the ITU (International Telecommunication Union).

Frequency ranges are globally specified as follows:

- VHF (very high frequency): 30 MHz to 300 MHz;
- UHF (ultra high frequency): 300 MHz to 3 000 MHz.

The allotted frequency ranges are different from country to country.

The number of central frequencies (the number of channels) that can be used in a region or country is usually limited. Usually, one central frequency (one channel) is jointly used by a number of remote telemetry stations. To avoid interference, neighbour systems cannot adopt the same frequency group. The frequency for communication should follow the local regulations and laws. For event reporting, collision from the same frequency is not avoidable; reasonable allocation of frequencies can reduce this interference.

There are analogue and digital systems.

Radio communication equipment controls transmitting and receiving of radio signals so that link connection is established.

The transmission speed is usually 200 bps to 1 200 bps on an analogue system used for voice communication by frequency shift keying (FSK). The transmission speed on a digital system or analogue system by minimum shift keying (MSK) or Gaussian MSK (GMSK) is usually 1 200 bps to 9 600 bps.

## F.8 Multiplex radio communication links

The effective use of frequencies is available worldwide under the control of the ITU (International Telecommunication Union).

The available frequency range extends from UHF to SHF<sup>1)</sup> (300 MHz to 30 GHz).

The allotted frequency range is different from country to country.

These links are used for multi-channel telephone communications and high-speed data communications.

There are analogue and digital links. The links that do not pass through exchanges are always connected.

## F.9 Satellite communication links

Very Small Aperture Terminal (VSAT) and International Maritime Satellite Organization (INMARSAT) are typical satellite communication links for data transmissions. There are other satellite communications available, but these vary from country to country.

Since satellites are used as relay stations, international communications as well as domestic communications are available.

The digital circuits via VSAT can also provide voice conversation.

The transmission speed via VSAT varies depending on the class of service, but it is over 9 600 bps.

The transmission speed on INMARSAT varies depending on the class of service, but is over 200 bps.

Transmission signals may attenuate during heavy rains and communications may not be available.

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1) SHF is super high frequency.

## Annex G (normative)

### Design of VHF/UHF radio link

#### G.1 General

This annex specifies the methods of designing VHF/UHF radio links and the points to be considered.

#### G.2 Prerequisites

The radio frequencies in the VHF/UHF bands are the most widely used. In general, radio frequencies are assigned by making an application to the authority controlling the radio frequencies. When the emission and receiving points are on a line of sight, the communication distances are decreased from the VHF band to the UHF band.

#### G.3 Radio circuit design

##### G.3.1 Determining quality standards

The signal to noise ratio (S/N) values shall be determined in advance. These values are used to judge whether the quality of the radio circuit can satisfy the required quality standards. If the measured S/N values are lower than the designed S/N value, measures (such as relocating the station or setting up a relay station) should be taken.

##### G.3.2 Radio path study

###### G.3.2.1 General

In general, the following procedure is used for a desk study of radio path.

###### G.3.2.2 Preparing terrain profiles

Prepare the terrain profiles by analysing the route topography on scale maps (normally, the scale is 1:50 000) or using a digital map database.

###### G.3.2.3 Calculating propagation losses

Calculate the propagation losses by considering each of the following losses:

- a) free-space loss, which is determined by the distance and frequency used;
- b) diffraction loss, which is determined by the depth of maximum diffraction along the line between two points of emission and receiving, and the distances from the diffraction point to the emission point and the distance to the receiving point;
- c) other losses, which are plane-earth and spherical-earth losses.

#### G.3.2.4 Determining specifications of equipment

Determine the transmission output and the type, direction and necessary height of an antenna to satisfy the design S/N value, taking into consideration the characteristics of the receiver (such as the receiver noise power and the S/N improvement factor), the antenna angle loss and the antenna system loss.

The points that should be considered in designing radio circuits are described below.

- When a lot of interference is anticipated, the loss at a rejection filter should be considered.
- When remote telemetry stations are distributed over a wide area, antennas that have wide beam-widths should be selected and oriented to the site with the worst design S/N.
- The higher the output power of the transmitter, the better is the quality of transmission, and the smaller are the effects from other systems. However, such a transmitter may cause interference to other systems. The minimum necessary output power should be implemented.

#### G.3.3 Radio propagation tests

The actual radio propagation may differ from the radio path study due to buildings, trees and environmental noises that cannot be determined in the radio path studying. Radio propagation tests should be conducted at candidate sites of emission, receiving and relay stations.

The survey should include S/N measurements, field strength (received power) measurements and external noise field strength measurements. If necessary, the horizontal and vertical antenna patterns should be investigated. Interferences on the scheduled frequencies should also be monitored.

These survey results are fed back to correct the desk design values and determine the types of antenna and the output power of the transmitter.

Finally, a test report of radio link should be presented.