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Electricity metering – Payment systems –

Part 21: Framework for standardization

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ELECTRICITY METERING – PAYMENT SYSTEMS –

Part 21: Framework for standardization

FOREWORD

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Technical reports do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful by the maintenance team.

IEC 62055-21, which is a technical report, has been prepared by Technical Committee 13: Equipment of electrical energy measurement and load control.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
13/1318A/DTR	13/1325A/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 62055 consists of the following parts, under the general title *Electricity metering – Payment systems:*

Part 21: Framework for Standardization

Part 31: Particular requirements – Static payment meters for active energy (classes 1 and 2)

Part 41: Standard Transfer Specification – Application layer protocol for one-way token carrier systems

Part 51: Standard Transfer Specification – Physical layer protocol for one-way numeric and magnetic card token carriers

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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  withdrawn,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

INTRODUCTION

There is widespread activity in the application and development of payment metering systems in IEC member countries. Whilst there are many similarities in equipment functionality and operation of electricity payment metering systems in these countries, there is divergence in the particular payment technology used as well as in the use of particular token carrier technologies. An example of this is the large number of solutions using disposable magnetic cards.

A need has been identified to describe the various systems and their elements in a coherent manner and to provide a framework for standardization of payment metering systems, their elements and interfaces.

This technical report thus seeks to meet the following objectives:

a) to present a systematic methodology to follow for use by suppliers to produce requirements specifications for system procurement;

b) to present a systematic methodology to follow for use by equipment manufacturers to produce specifications for systems and products;

c) to present a standard way in specifying system requirements or functionality in order that such specifications may be easily compared and evaluated by manufacturers and users;

d) to ensure that such specifications are produced in an “open” format to allow the interoperability of sub-system components.

It has to be noted that it is not the intention of this technical report that there should be only one standard for payment metering systems or sub-systems, but that it should provide guidelines for defining several such standards according to the specific needs of the industry as and when these are identified.

The standardization work of TC13 WG15 should follow the guidelines given in this technical report in order to present such standards in a coherent and systematic way that meets the above objectives.

The IEC 62055 series covers payment systems, encompassing the customer information systems, point of sales systems, token carriers, payment meters and the respective interfaces that exist between these entities.

ELECTRICITY METERING – PAYMENT SYSTEMS –

Part 21: Framework for standardization

1 Scope

This technical report sets out a framework for the integration of standards into a system specification for electricity payment metering systems. It addresses the payment metering system application process, generic processes, generic functions, data elements, system entities and interfaces that exist in present payment metering systems. The approach taken in the framework is sufficiently generic to payment metering systems so that it should be equally applicable to future systems.

NOTE 1 This technical report excludes the application of coin-operated meters in payment systems.

NOTE 2 This technical report specifically covers electricity metering payment systems. However, it is recognised that payment metering is an established requirement in other utility services and the general framework for standardization in this technical report can be applied to such other utility services.

NOTE 3 Contract functions are confined to single bi-lateral supply agreements between a supplier and a customer and specifically exclude related third party agreements such as may be found in the deregulated markets.

NOTE 4 Future aspects are considered in Clause 9.

2 References

IEC 60050-300: *International Electrotechnical Vocabulary (IEV) – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements – Part 312: General terms relating to electrical measurements – Part 313: Types of electrical measuring instruments – Part 314: Specific terms according to the type of instrument*

IEC 62051:1999, *Electricity metering – Glossary of terms*

IEC 62055-31, *Electricity metering – Payment systems – Part 31: Particular requirements – Static payment meters for active energy (classes 1 and 2)* [1]

IEC/PAS 62055-41:2003, *Electricity Metering – Payment metering systems – Part 41: Standard Transfer Specification*

— NRS 009-6-6: *Interface Standards – Standard Transfer Specification / Credit dispensing unit – Electricity dispenser – Categories of tokens and transaction data fields*

— NRS 009-6-7: *Interface Standards – Standard Transfer Specification / Credit dispensing unit – Electricity dispenser – Token encoding and data encryption and decryption*

— NRS 009-6-8: *Interface Standards – Standard Transfer Specification / Disposable magnetic token technology – Token encoding format and physical token definition*

— NRS 009-6-9: *Interface Standards – Standard Transfer Specification / Numeric token technology – Token encoding format and physical token definition*

— NRS 009-7: *Standard transfer specification / The management of cryptographic keys*

[1] To be published.

IEC 62055-41, *Electricity Metering – Payment metering systems – Part 41: Standard Transfer Specification – Application layer for one-way token carrier systems* [1]

IEC 62055-51, *Electricity Metering – Payment metering systems – Part 51: Standard Transfer Specification – Physical layer for one-way numeric and magnetic card token carrier systems* [1]

IEC 62056-21:2001, *Electricity metering – Data exchange for meter reading, tariff and load control – Part 21: Direct local data exchange*

IEC 62056-46:2002, *Electricity metering – Data exchange for meter reading, tariff and load control – Part 46: Data link layer using HDLC protocol*

IEC 62056-47, *Electricity metering – Data exchange for meter reading, tariff and load control – Part 47: COSEM transport layers for IPv4 networks*[2]

IEC 62056-53:2002, *Electricity metering – Data exchange for meter reading, tariff and load control – Part 53: COSEM application layer*

IEC 62056-61:2002, *Electricity metering – Data exchange for meter reading, tariff and load control – Part 61: Object identification system (OBIS)*

3 Terms and definitions

For the purposes of this document, the definitions and terms given in IEC 60050-300, IEC 62051, IEC 62055-31 and the following terms apply.

Where there is a difference between the definitions in this technical report and those contained in other referenced IEC standards, then those defined in this technical report shall take precedence.

3.1 Definitions

3.1.1
token
subset of data elements, containing information that is present in the APDU of the application layer of the POS_to_Token_Carrier_Interface, and which is also transferred to the meter by means of a token carrier, and which is finally presented to the meter application process

The converse is also true in the case of a token being sent from the meter to the POS.

3.1.2
token carrier
medium that is used in the physical layer of the POS_to_Token_Carrier_Interface, onto which the token is modulated or encoded, and which serves to carry the token from the point where it is generated to the remote meter, where it is received

3.1.3
location
geographical area, clearly distinguishable from another adjacent area, on which the payment meter is installed

Examples of such locations are: consumer's premises, building, street or pavement.

3.1.4
local
term defined in relation to the physical location of the payment meter installation

Any device that is on the same location as the payment meter is considered to be local.

3.1.5
remote
term defined in relation to the physical location of the payment meter installation

Any device that is not on the same location as the payment meter is considered to be remote.

3.1.6
supplier
legal entity that enters into a contractual supply agreement with a customer to effect delivery of electrical energy or other utilities

NOTE Other definitions of “supplier” may be relevant in deregulated markets.

3.1.7
transaction record
group of data elements describing the necessary attributes of a financial transaction

This would normally include items like transaction amount, purchase item identifier, kWh value, payment type, receipt number, customer reference number, operator number, shift batch number, sales batch number, banking batch number, etc.

3.1.8
shift batch
group of transaction records created during a single working shift of a particular POS operator

3.1.9
shift batch summary
summary of transactions in a shift batch, summarized by transaction type and optionally by service type and by the supplier

NOTE It is common practice for an agent to perform the receipting function for several supply companies, thus requiring transaction records to be separated per supplier. A single supplier such as a municipality that supplies water and electricity also requires transaction records to be separated per service type.

3.1.10
sales batch
group of shift batches

3.1.11
sales batch summary
summary of transactions in a sales batch, summarized by shift batch and by transaction type and optionally by service type and by the supplier

3.1.12
banking batch
group of sales batches

3.1.13
banking batch summary
summary of transactions in a banking batch, summarized by sales batch, by shift batch and by transaction type and optionally by service type and by the supplier.

It includes bankable amounts totalled by payment type (and optionally by service type and by the supplier) in preparation for bank depositing and settlement with each supplier.

3.1.14
process
logically linked sequence of tasks that enables the system to achieve particular objectives

For definition of various processes, see Clause 10.

3.1.15
function
encapsulation of a defined capability or functionality of the system

For definition of various functions, see Clause 11.

3.2 Abbreviated terms

3DES	Triple DES (see also DES); Data Encryption Standard applied 3 times
AES	Advanced Encryption Standard
AMR	Automatic Meter Reading
APDU	Application Protocol Data Unit
ASN	Abstract Syntax Notation
BS	British Standard
CDROM	Compact disc read-only memory
CDU	Credit Dispensing Unit (see also POS)
CIS	Customer_Information_System
CRC	Cyclic_Redundancy_Code
CRT	Cathode-ray tube
C/S	Client / Server
DES	Data Encryption Standard
DIN	Deutsches Institut für Normung; a Germany-based standards organization
DLMS	Device Language Message Specification
ED	Electricity Dispenser or Energy Dispenser; used in Annex A interchangeably with “meter”
GMT	Greenwich Mean Time
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
HO	high-order portion of a number
HTML	Hyper Text Mark-up Language; a standard format for web documents
ID	Identifier or identification
IEC	International Electrotechnical Commission
IEC/PAS	IEC – Publicly Available Specification
ISO	International Standards Organization
kWh	kilo-watt hour
LAN	Local Area Network
LCD	Liquid-crystal display
LED	Light emitting diode
LO	low-order portion of a number

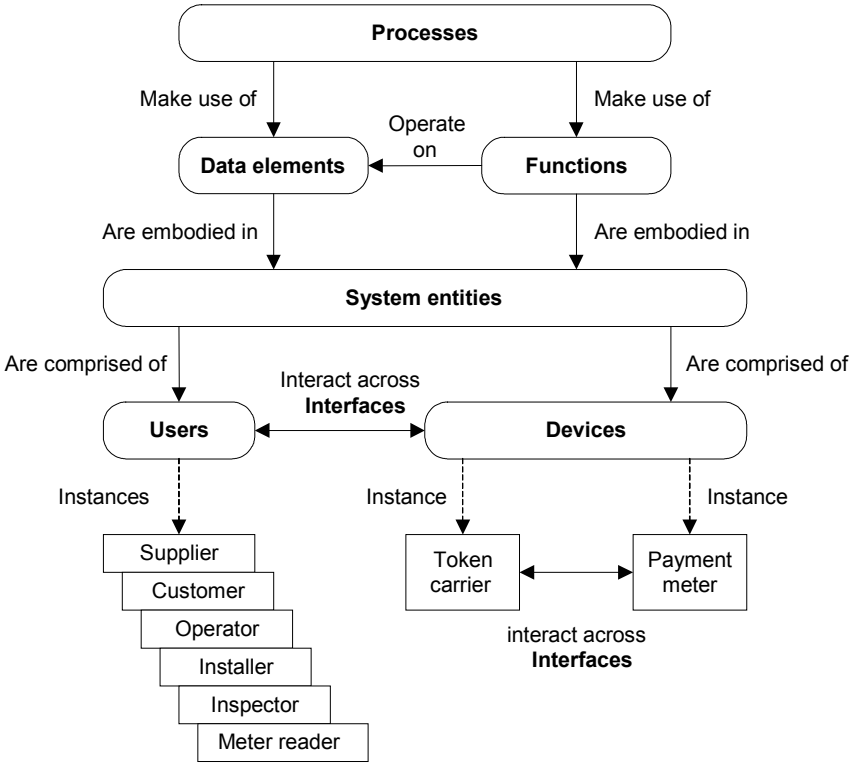
NRS	National Rationalized user Specification; a South African industry standard
OSI	Open System Interconnection; a reference model for communication protocols
PAN	Primary_Account_Number
PLC	Power Line Carrier
POD	Point_Of_Delivery
POS	Point_Of_Sale (see also CDU)
PSTN	Public Switched Telephone Network
RAM	Random Access Memory
RAS	Remote Access Server
RSA	A public key cryptography standard; Authors: Rivest, Shamir and Adelman
STS	Standard Transfer Specification
STT	Standard Token Translator; converts an STS format token into a specified proprietary format token
TC13	IEC Technical Committee 13
TCP/IP	Transmission Control Protocol / Internet Protocol
TID	Token_Identifier
TV	Television
WAN	Wide Area Network
WG15	Working Group 15 of IEC TC13
X.25	A standard for packet switching networks; layers 1, 2 and 3 in OSI model
XML	Extensible Mark-up Language; a standard format for data exchange

3.3 Notation and terminology

Throughout this technical report the following rules are observed regarding the naming of terms:

- entity names, data element names, function names and process names are treated as generic object classes and are given names in terms of nouns, which are capitalized and joined with an underscore to signify a single entity. Examples are: Supply_Group_Code as a data element name, Encryption_Algorithm as a function name and Installation_ Connection as a process name;
- direct (specific) reference to a named class of object uses the capitalized form, while general (non-specific) reference uses the small caps form without underscore joining. A direct reference example is: “The Supply_Group_Code is linked to a group of meters”, while an indirect reference example is: “A supply group code links to a vending key”;
- other terms use the generally accepted abbreviated forms like PSTN for Public Switched Telephone Network.

4 General concepts



NOTE With outsourced services or deregulated market environments, there may be additional user instances such as vending agents and retail network services providers.

Figure 1 – General concepts of a Payment Metering System

A Payment Metering System is a collective infrastructure that supports the contractual relationship between a supplier of goods or services and a customer. It includes processes, functions, data elements, system entities (devices and users) and interfaces.

A Process is a logically linked sequence of tasks and activities that enable the system to achieve particular objectives in terms of the purpose for which it is designed. A process calls on the services of functions, which in turn operate on data elements. A process may also interact with other processes, (e.g. being invoked or terminated by another process) or it may invoke several functions to achieve a particular result. Because a particular function may be used by more than one process, there may be many more processes in a system than there are functions. See also Clause 10 for more on generic processes.

A Function is the encapsulation of a defined capability or functionality of the system, abstracted from the application domain, that gives the system entities the ability to act, react and interact. The internal working of a function is itself a process, but this is invisible from an external perspective, which sees only a start and end state. A process may thus also be encapsulated into a single function. A function is always embodied in one or more of the system entities and may even require several entities in order to realize a particular function. It is a well-defined task with a start and end state that, when invoked, will cause the task to be executed until completion. The end result of a function may be anything from a simple data manipulation, through calculating the answer of a complex mathematical problem, to the displaying of the contents of a particular register. It is important to note that a given function may not necessarily be implemented in the same physical part or system entity of a particular system as compared to that of another system even if the functions are identical. See also Clause 11 for more on generic functions.

Data Elements embody information about the properties or status of the system. They are the most basic part of the system and should not be decomposed below this definition. Data elements may vary from being the contents of a software register to being a visible marking on a label of a meter panel indicating a meter serial number. Data elements are created, recorded, transformed and moved around within the system by means of processes and functions. See also Clause 12 for more on data elements.

System Entities are discrete devices and users of the system that are deployed and configured within a system architecture in such a way as to enable the system to perform it's objectives. Devices are typically computers, modems, networks, printers, token carriers, meters, software programs, etc. Each of these entities embodies functions and data elements that participate in processes. Similarly users are typically customers, POS operators, installation and maintenance personnel, etc. See also Clause 13 for more on system entities.

Interfaces will exist between those system entities that need to exchange data elements. These interfaces will have data elements passing over them in support of the functions and processes. Interfaces are selected at appropriate places within a defined architecture to suit a clear objective of the system design. See also Clause 13 for more on interfaces.

5 The generic entity model

A generic entity model for electricity payment metering systems is shown in Figure 2. Although it provides a limited perspective, it does serve to convey certain essential concepts.

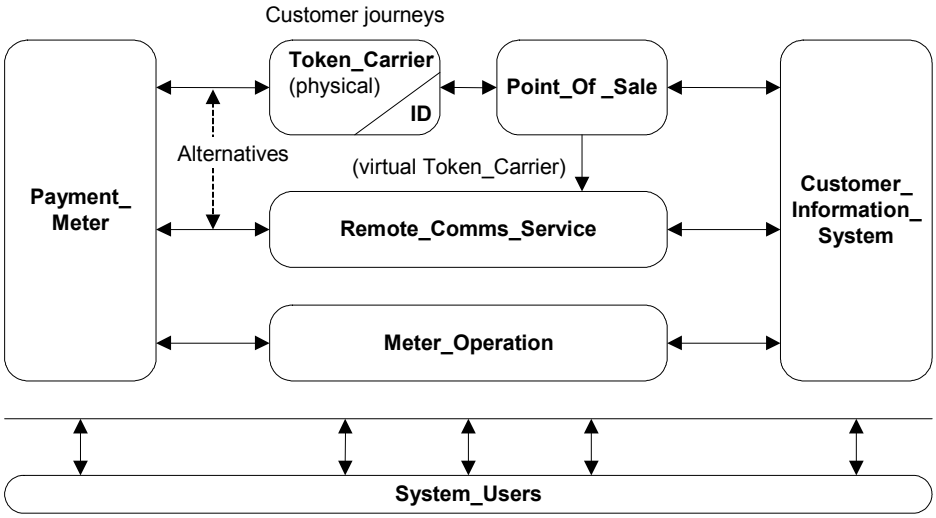


Figure 2 – Generic entity model for electricity payment metering systems

The essential entities of a payment metering system are:

- the Payment_Meter;
- the Token_Carrier or Remote_Communication_Services providing the means to communicate with the Payment_Meter;
- the Meter_Operation providing the means to install a payment meter and to configure its variable parameters;
- the Point_Of_Sale where a customer interfaces with the supplier to conduct transactions;
- the Customer_Information_System;
- the System_Interfaces where the various entities interact;
- the System_Users (operators, installers, inspectors, customers, meter readers, etc).

NOTE 1 Independent retail network service providers and other service providers may also exist, especially in deregulated markets.
NOTE 2 System entities and interfaces are further discussed in Clause 13, except Customer_Information_Systems, Meter_Operation and Remote_Communication_Services because these are application specific and general guidelines cannot be given.

6 Generic functions and application process reference model for the Payment_Metering_System

6.1 Reference model

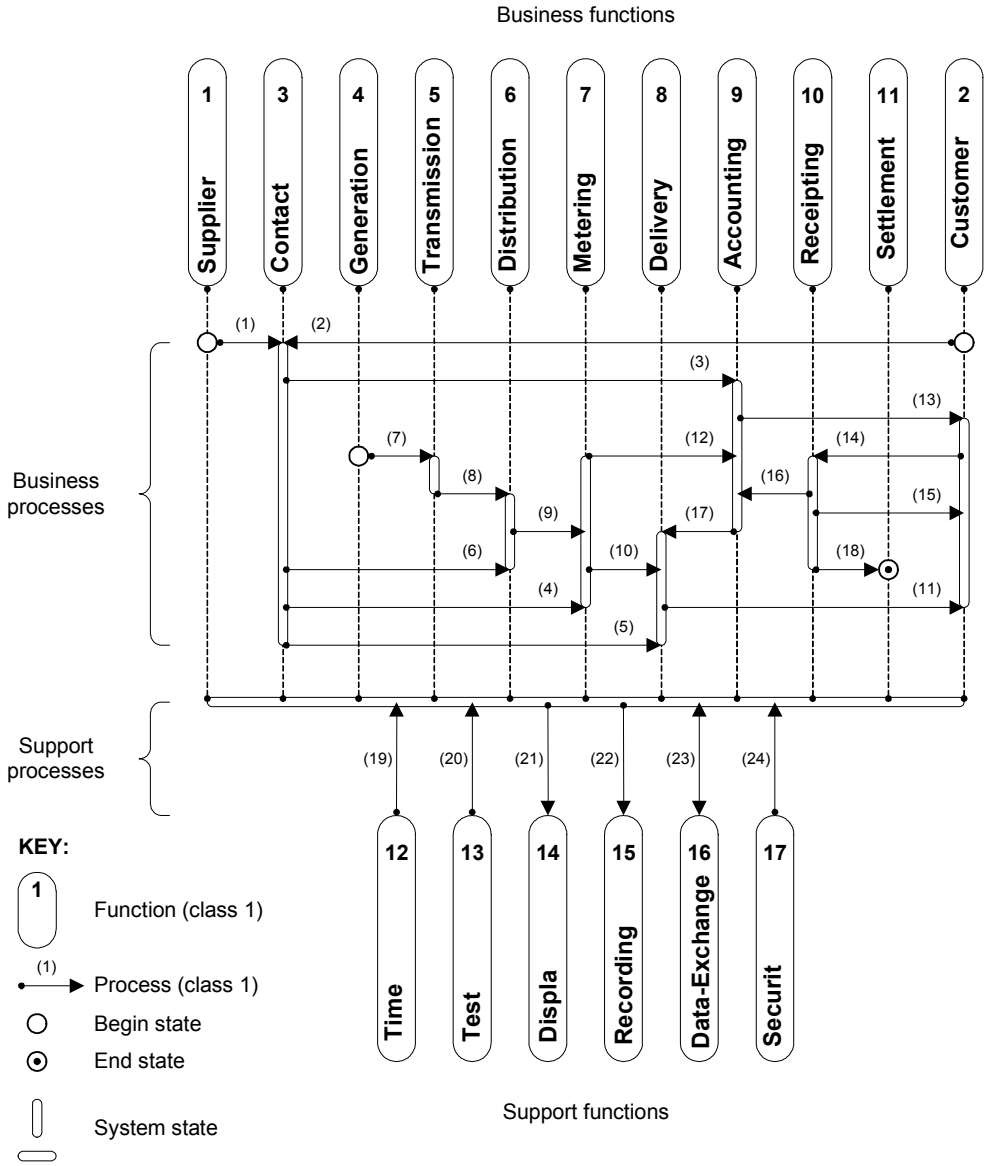


Figure 3 – Generic function model and application process for payment metering systems

6.1.1 Legend of symbols used in the reference model

A **function box** is an object-oriented representation (see 11.18) of a generic functional aspect of a payment metering system. For example: the Contract function represents all those aspects of the system that participate in providing the system with the capability to capture and enforce the business rules in accordance with the terms and conditions of the supply and purchase agreement between the Supplier and the Customer.

An **arrow** represents a process, which is an interactive relationship between two function objects. For example: process (6) manifests as the relationship between the Contract function and the Distribution function and is named Connection_Authorization.

The **dot** on the arrow represents the causal starting point of the process and the **head** represents the conclusive end point of the process. For example: process (3) is started by the Contract function and results in the establishment of a customer account within the Accounting function, which is the conclusive end of process (3).

A **system state box** represents a particular condition that a function enters into when a given event in the system causes it to do so. Such a condition is then a pre-requisite before other related events may be initiated. For example: process (1) and (2) are both required to instantiate a state in the Contract function, from which processes (3), (4), (5) and (6) may be started.

A **begin state circle** simply represents a starting point for a process that does not require a prior condition in order for it to start. For example: processes (1) and (2) may start at any time under the volition of the Supplier or the Customer.

An **end state circle** represents a condition of a function that does not cause any further events in the system and is the logical conclusion of a process. For example: process (18) ends at the Settlement function when the receipted payments from customers are handed to the supplier and there are hence no further actions to be taken from that point.

Between the business functions and the support functions there is a **common system state** (horizontal bar) that joins all the functions (1 to 17), and which serves to signify that the support functions have a relationship with each of the business functions by means of the support processes. However, each of the support functions in turn also has a relationship with the other support functions by means of the support processes. For example: the Time function serves the Accounting function with time information for controlling its time-based tariff schedules and also serves the Recording function with date and time information for tagging the data records where applicable.

6.1.2 Composition of the reference model

The multitude of functions in a payment metering system can be grouped and then abstracted into generic functions as depicted in Figure 3. This abstract function model is thus a generic representation of the functions in a payment metering system, from which all instances of specific systems are derived. Each generic function is allocated a class number (1 to 17), according to which all sub-functions are further classified, each sub-function thus inheriting its class from its generic parent function. Functions of class 1 to 11 are the business functions, while class 12 to 17 are support functions. A business function is one that implements application-specific business-related logic, while a support function is one that enhances the functionality of the business functions and also that of other support functions. It can thus be seen that one business function has a very specific interactive relationship with another business function, while a support function has a more general relationship with other functions and may interact with any other business function or with any other support function.

6.2 Business functions

The business functions are those that participate directly in the business rules of the application and enable the system to do what it is designed for. Thus they facilitate the delivery of goods and services in terms of the conditions of the supply and purchase agreement between the Supplier and the Customer.

With reference to Figure 3, the generic payment metering system application process employs the following generic business functions.

Table 1 – Generic business functions

Reference to items in Figure 3	Function
(1)	Supplier
(2)	Customer
(3)	Contract
(4)	Generation
(5)	Transmission
(6)	Distribution
(7)	Metering
(8)	Delivery
(9)	Accounting
(10)	Receipting
(11)	Settlement

See Clause 11 for a definition of each of these business functions.

6.3 Support functions

The support functions are those that enhance the functionality of the system and provide the basic foundation for the realization of the business functions of the system. Thus they do not participate directly in the business application.

With reference to Figure 3, the generic payment metering system application process employs the following generic support functions.

Table 2 – Generic support functions

Reference to items in Figure 3	Function
(12)	Time
(13)	Test
(14)	Display
(15)	Recording
(16)	Data_Exchange
(17)	Security

See Clause 11 for a definition of each of these support functions.

6.4 Business processes

The business processes are those activities that participate directly in the application of the particular business rules of the system. Thus they are primarily interactions between the business functions (see 6.2).

With reference to Figure 3, the generic payment metering system application process employs the following generic business processes.

Table 3 – Generic business processes

Reference to items in Figure 3	Process
(1)	Supply_Agreement
(2)	Purchase_Agreement
(3)	Account_Configuration
(4)	Metering_Configuration
(5)	Delivery_Configuration
(6)	Connection_Authorization
(7)	Transmission_Delivery
(8)	Distribution_Delivery
(9)	Installation_Connection
(10)	Point_Of_Delivery_Connection
(11)	Customer_Delivery
(12)	Meter_Reading
(13)	Customer_Billing
(14)	Payment_Receipting
(15)	Receipt_Issuing
(16)	Credit_Transfer
(17)	Delivery_Regulation
(18)	Supplier_Settlement

See Clause 10 for a definition of each of these business processes.

6.5 Support processes

The support processes are those activities that do not participate directly in the application of the business rules of the system, but provide supporting services to the business functions and processes. Thus they are interactions between the business functions (see 6.2) as well as between support functions (see 6.3).

With reference to Figure 3, the generic payment metering system application process employs the following generic support processes.

Table 4 – Generic support processes

Reference to items in Figure 3	Process
(19)	Time_Provision
(20)	System_Testing
(21)	Information_Display
(22)	Information_Recording
(23)	Data_Exchange
(24)	Security_Enforcement

See Clause 10 for a definition of each of these support processes.

6.6 Payment_Metering_Application process

The Payment_Metering_Application process is the combination of the business and support processes as the resultant interactions between the business and support functions, which thus describes the dynamic behaviour of the system as a whole.

The Supply_Agreement process(1) and the Purchase_Agreement process (2) capture the terms and conditions of supply and the terms and conditions of purchase in the customer Contract function. The participating parties are the Supplier and Customer or their legal representatives.

The Contract function enforces the terms and conditions by means of the Account_ Configuration process (3) that instantiates the customer's account within the Accounting function. In turn, the Metering_Configuration process (4) ensures that the appropriate configuration of Metering equipment is installed and similarly the Delivery_Configuration process (5) ensures that the appropriate Delivery equipment is installed and configured at the customer's premises. Once the customer's installation is completed, the Connection_ Authorization process (6) instructs the Distribution function to connect the customer's meter installation to the distribution network, which takes place by means of the Installation_ Connection process (9).

The Generation function represents the source of the electrical energy supply and the Transmission_Delivery process (7) transfers the electrical energy from the generator to the transmission grid. The Transmission function makes the electrical energy available at the grid exit points, where the Distribution_Delivery process (8) similarly transfers it to the distribution network. The Distribution function makes the electrical energy available at the customer's premises for connection to the customer's meter installation.

NOTE The Supplier function has a commercial relationship with the Customer function and may also have other contractual agreements with the Generation function, Transmission function or Distribution function, but these contracts fall outside the scope of this model and technical report.

Once the customer's meter installation is connected to the distribution network the Point_Of_Delivery_Connection process (10) supplies metered electrical energy to the Delivery function from where the Customer_Delivery process (11) delivers it to the customer's load circuit.

The Meter_Reading process (12) obtains measurements of the delivered quantities of electrical energy from the Metering function and transfers it to the Accounting function for calculation and transacting of appropriate charges to the customer's account.

In a post-payment system the Customer_Billing process (13) will issue a request for payment (or credit) to the customer in the form of a bill or invoice. Whereas in a pre-payment system the Delivery_Regulation process (17) ensures that the quantity of electrical energy that is delivered to the customer is in accordance with the available credit balance in his account. It will typically cause the delivery of electrical energy to be interrupted when the available credit expires and allow it to be restored when the available credit is replenished.

The customer makes a payment by means of the Payment_Receipting process (14) and the Receipt_Issuing process (15) provides the customer with a proof of payment, usually in the form of a transaction receipt. The Credit_Transfer process (16) transfers payment credit to the customer's account in accordance with the payment amount. In a post-payment system this may be in the form of a journal entry into a bookkeeping system, while in a pre-payment system it is typically in the form of a credit token for transfer to the payment meter by means of a token carrier.

At some point in time the Supplier_Settlement process (18) will transfer the receipted payments to the supplier, which is typically in the form of bank deposits into the supplier's bank account.

The Time_Provision process (19) makes date and time information available to the other system functions where those functions control time-based schedules.

The System_Testing process (20) checks and validates the correct working of other system functions.

The Information_Display process (21) facilitates viewing of recorded information by users of the system.

The Information_Recording process (22) facilitates capturing and storing of information and events within the payment metering system.

The Data_Exchange process (23) moves data elements between functions deployed in system entities over interfaces using defined protocols.

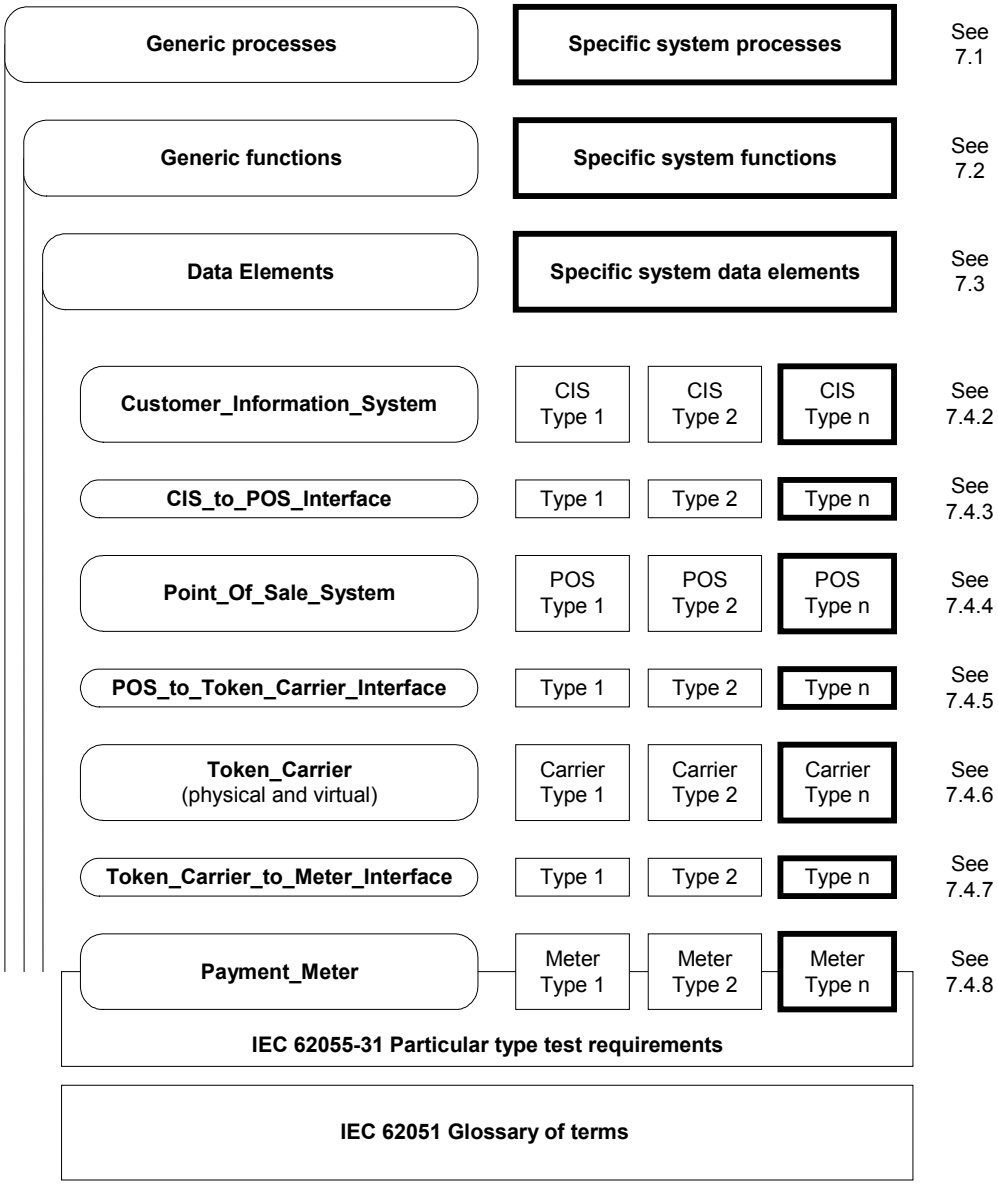
The Security_Enforcement process (24) enforces the security policies onto other relevant system functions and thus assures the integrity of the payment metering system.

Each generic process is allocated a class number (1 to 24), according to which all sub-processes are defined, each sub-process thus inheriting its class from its generic parent process.

Every instance of a process in a particular payment metering system will thus be classified according to one of the generic process classes.

It must be noted that because a function is an encapsulated process, the distinction between a function and a process is not always clear and it depends solely on how the definition is formulated. In principle, a function definition is a statement of a capability and a process definition is a statement of a sequence of tasks or events.

7 Framework for standardization



NOTE An interface from the CIS to the Token_Carriers may also exist and the CIS may also have an alternative communication service to the Payment_Meters.

Figure 4 – Framework for standardization in electricity payment metering systems

In the setting up of standards for any particular payment metering system, it is necessary to consider the physical entities, interfaces, data elements, functions and processes.

Figure 4 proposes a framework for standardization in electricity payment metering systems. The rounded boxes indicate generic elements and the squared boxes indicate specific instances. The dark outlined boxes illustrate a comprehensive payment metering system specification. Sub-system instances are also possible. For example: a POS, token carrier and meter with their respective interfaces can also be specified as a particular instance of a sub-system implementation.

It should also be noted that processes, functions and data elements are defined at the systems level as well as at each entity and interface, thus the framework dictates that any specification for an entity or interface should include reference to the functions and data elements. Conversely, a specification for a particular instance of a process should include reference to the functions and data elements that participate in the process. Similarly, a specification for a function should include reference to the data elements that it operates on.

The development of payment metering system standards should broadly follow the following process:

- when existing industry standards are proposed to the IEC for incorporation into the IEC 62055 set of standards, it would be necessary to formulate the proposed industry standards in terms of the framework for standardization and definitions given in this technical report. This would then be an instance of a particular industry standard for interfaces, data elements, functions, processes and entities like meters, token carriers and POS or CIS implementations. In this way, it gives opportunity for multiple systems to be standardized, while ensuring open standard specifications to the industry.

7.1 Generic processes

See Clause 10 for a more complete definition of generic processes that are found in payment metering systems and those activities that are required to operate a payment metering system. Any specific system or sub-system implementation would employ only some or all of these processes as particular instances of the generic processes. The standardization process of new work item proposals should involve transforming such proposals into the formats as defined in this framework as specific processes of such a specific system or sub-system. The classification scheme given in this framework should be used as the parent class for any sub-process definition.

7.2 Generic functions

See Clause 11 for a more complete definition of the generic functions that are found in payment metering systems. Any specific system or sub-system implementation would employ some or all of these functions as particular instances of the generic functions. The standardization process of new work item proposals should involve transforming such proposals into the formats as defined in this framework as specific functions of such a specific system or sub-system. The classification scheme given in this framework should be used as the parent class for any sub-function definition. This is particularly relevant to the IEC 62055-31 type test requirements for payment meters.

7.3 Data elements

See Clause 12 for a more complete definition of the data elements that are found in payment metering systems. Any specific system or sub-system implementation would employ only some or all of these data elements as particular instances of the generic data elements. The standardization process of new work item proposals should involve transforming such proposals into the formats as defined in this framework as specific data elements of such a specific system or sub-system.

7.4 System entities and interfaces

7.4.1 General

See Clause 13 for a more complete description and definition of system entities and interfaces.

7.4.2 CIS: Customer_Information_System

See 13.1 for a more complete description and definition of the customer information systems. Customer information systems should be defined in terms of data elements, functions, processes and interfaces within the context of the system as defined in this framework.

7.4.3 CIS_to_POS_Interface

See 13.2 for a more complete description and definition of this interface.

Interfaces should be defined in terms of data elements, functions and processes within the context of the system as defined in this framework.

It should be structured as an application layer and a physical layer in terms of the OSI reference model with optionally one or more intermediate layers. Functions and data formats are defined in each of the layers.

7.4.4 POS: Point_Of_Sale

See 13.3 for a more complete description and definition of point of sale infrastructure.

A point of sale should be defined in terms of data elements, functions, processes and interfaces within the context of the system as defined in this framework.

7.4.5 POS_to_Token_Carrier_Interface

See 13.4 for a more complete description and definition of this interface.

Interfaces should be defined in terms of data elements, functions and processes within the context of the system as defined in this framework.

It should be structured as an application layer and a physical layer in terms of the OSI reference model with optionally one or more intermediate layers. Functions and data formats are defined in each of the layers.

7.4.6 Token_Carrier

See 13.5 for a more complete description and definition of token carriers.

A token carrier should be defined as the medium in the physical layer of the POS_to_Token_Carrier_Interface and the Token_Carrier_to_Meter_Interface within the context of the system as defined in this framework.

NOTE In some two-way virtual token carrier based systems, there may be also a CIS_to_Token_Carrier_Interface for the remote communication services involved.

7.4.7 Token_Carrier_to_Meter_Interface

See 13.6 for a more complete description and definition of this interface.

Interfaces should be defined in terms of data elements, functions and processes within the context of the system as defined in this framework.

It should be structured as an application layer and a physical layer in terms of the OSI reference model with optionally one or more intermediate layers. Functions and data formats are defined in each of the layers.

7.4.8 Payment_Meter

See 13.7 for a more complete description and definition of payment meters.

Payment meters should be defined in terms of data elements, functions, processes and interfaces within the context of the system as defined in this framework.

8 Example specification for a payment metering system

See Annex A for an example of a requirement specification for a payment metering system based on an existing system using one-way token carriers and transferring energy credit units.

In this example, the functions, processes and data elements are kept together in order to retain the context with the devices or entities at the point where these are specified. The example is an outline of requirements only and serves to illustrate the principles of using the framework for standardization as defined in this technical report.

Clauses A.3, A.4 and A.5 merely give the essence of the CIS, POS and interface functions with some essential data elements.

Clauses A.6, A.7 and A.8 give a fairly comprehensive example for the interface between the point of sale, the token carrier and the meter. The example given is based on a current implementation for one-way token carriers using the IEC/PAS 62055-41 protocol.

Clause A.9 gives a fairly comprehensive example of a single-part payment meter installation. Because of the fragmented nature of the relevant reference specifications, these have not been reproduced, but are merely referenced from within the text.

9 Future aspects

Items relating to the standardization of payment metering systems that might need to be addressed in the future are:

a) as each industry specification is proposed to the IEC for standardization, further work will be required from the WG15 to transform these into the format specified by this technical report;

b) the adequacy of this technical report will be tested once the first transformation work is attempted. Some details may have to be altered or added once the first attempt is made and it will be further tested when many variants of payment metering systems are worked on. This is likely to be the case with two-way virtual token carrier based systems, for example;

c) there may be a need to align payment metering system specifications with that of relevant parts of the DLMS-COSEM-OBIS specification as defined in the IEC 62056 series;

d) the emerging needs of the deregulated electricity supply industry may require a revised approach to this model of the payment metering system. Issues pertaining to the arbitration and settlements of bills between the Generation Companies, Transmission Companies, Distribution Companies, Meter Operators, Suppliers/Retailers and Customers may have to be addressed, for example.

10 Generic processes

See also Clause 4 for a discussion on general concepts and Clause 6 on the generic payment metering system application process.

A process definition describes the flow of data elements or of a sequence of events, each being defined and distinguishable within the system. As a particular instance of a process progresses along it's life cycle, it changes (transitions) from one state to the next state, each state having clearly defined entry and exit criteria. A process will have one or more start and end states with one or more specified intermediate states. Each state entry or exit or transition is triggered by defined conditions and will employ the services of functions or will invoke other processes to operate on or to move data elements within the system. These functions may be embodied in several different, but mutually associated devices that are deployed within the system. A process may thus employ the services of several functions, several other processes, involve several different system users and devices and operate on several data elements during the life cycle of a particular process instance. A process may be defined in terms of a state diagram, a flow diagram or by means of a pseudo code such as ASN. Certain processes may be automated, which will execute without the intervention of a system user, while manual processes require the participation of a user.

Processes are classified according to the generic model shown in Figure 3 and Clause 6. It should be noted that although each process class indicates the singular in the generic sense, actual system implementations typically have several instances of processes that belong to the same class.

With reference to Clause 6 and Figure 3, the generic process classes are defined as follows.

Table 5 – Definition of generic process classes

Class	Process	Subclause
1	Supply_Agreement	10.1
2	Purchase_Agreement	10.2
3	Account_Configuration	10.3
4	Metering_Configuration	10.4
5	Delivery_Configuration	10.5
6	Connection_Authorization	10.6
7	Transmission_Delivery	10.7
8	Distribution_Delivery	10.8
9	Installation_Connection	10.9
10	Point_Of_Delivery_Connection	10.10
11	Customer_Delivery	10.11
12	Meter_Reading	10.12
13	Customer_Billing	10.13
14	Payment_Receipting	10.14
15	Receipt_Issuing	10.15
16	Credit_Transfer	10.16
17	Delivery_Regulation	10.17
18	Supplier_Settlement	10.18
19	Time_Provision	10.19
20	System_Testing	10.20
21	Information_Display	10.21
22	Information_Recording	10.22
23	Data_Exchange	10.23
24	Security_Enforcement	10.24

10.1 Class 1: Supply_Agreement process

The legal processes associated with agreeing and establishing the Supplier's terms and conditions of supply and capturing these in the Contract.

10.2 Class 2: Purchase_Agreement process

The legal processes associated with agreeing and establishing the Customer's terms and conditions of purchase and capturing these in the Contract.

10.3 Class 3: Account_Configuration process

The processes associated with establishing the customer's account within the accounting infrastructure and setting up the rules for the Accounting function in accordance with the Contract.

10.4 Class 4: Metering_Configuration process

The processes associated with installing the customer's metering equipment and the setting up of the metrological properties and rules for the Metering function in accordance with the Contract.

10.5 Class 5: Delivery_Configuration process

The processes associated with installing the customer's delivery equipment and the setting up of the rules for the Delivery function in accordance with the Contract.

10.6 Class 6: Connection_Authorization process

The processes associated with notifying and authorising the distribution network service provider to connect the customer's meter installation to the distribution network.

10.7 Class 7: Transmission_Delivery process

The processes associated with transferring the generated electrical energy from the generator into the transmission grid.

10.8 Class 8: Distribution_Delivery process

The processes associated with transferring the transmitted electrical energy from the transmission grid into the distribution network.

10.9 Class 9: Installation_Connection process

The processes associated with making available electrical energy from the distribution network to the customer's meter installation.

10.10 Class 10: Point_Of_Delivery_Connection process

The processes associated with supplying metered quantities of electrical energy to the customer's delivery mechanism.

Examples of these would include meter installation, meter removals, meter commissioning, meter de-commissioning, and relevant inspection processes.

NOTE 1 The Point_Of_Delivery (POD) is the point where the transfer of ownership of the electrical energy takes place and is where the customer's load circuit connects to the delivery equipment.

NOTE 2 In some deregulated markets, the Point_Of_Delivery may also be known as the Identification_ Connection_Point (ICP).

10.11 Class 11: Customer process_Delivery

The processes associated with transferring delivered electrical energy to the customer's load circuit.

Examples are: interruption and restoration of the supply to the customer's load. These may be automatic or manual and may be controlled locally or remotely.

10.12 Class 12: Meter_Reading process

The processes associated with obtaining measurements of the quantities of delivered electrical energy for the purpose of charging the customer's account.

In a system where the Accounting function is not located in the payment meter installation (i.e. remotely) this process may take place manually by meter readers or automatically by AMR. Where the Accounting function is located in the payment meter installation this process may take place automatically by direct connection between the Metering and the Accounting functions.

10.13 Class 13: Customer_Billing process

The processes associated with calculating the balance of charges due against payments made and issuing a request for payment (or credit) to the customer.

In a system where the Accounting function is not located in the payment meter installation this normally involves a printed bill that is sent to the Customer. Where the Accounting function is located in the payment meter installation a bill is normally not produced, but the supply to the customer's load circuit is interrupted instead. However in some cases a periodic statement may also be sent to the Customer.

10.14 Class 14: Payment_Receipting process

The processes associated with receiving payments from the Customer.

Implementation examples are: account payments and pre-paid token purchases, postal payments, operator assisted POS terminals, or automatic token vending machines.

10.15 Class 15: Receipt_Issuing process

The processes associated with providing the Customer with proof of payments received.

10.16 Class 16: Credit_Transfer process

The processes associated with transferring credit to the customer's account in accordance with payments made or other forms of credit grants.

For example: credit transferred by means of a pre-paid credit token to the payment meter accounting register, or by means of a journal entry into the debtor's ledger account in the case where the Accounting function is not located in the payment meter.

10.17 Class 17: Delivery_Regulation process

The processes associated with regulating the delivered quantity of electrical energy to the customer in accordance with available credit balance of his account.

In a system where the delivery function has a supply interruption facility this process is typically achieved by means of providing the available credit balance or issuing an instruction to the delivery function. Where the Delivery function does not have a supply interruption facility this process may be inactive.

10.18 Class 18: Supplier_Settlement process

The processes associated with transferring the receipted customer payments to the Supplier.

Examples are: cashing up and closing banking batch records, banking batch summary reports, drop-safe depositing, or handing to an agent, or depositing of funds at the bank, or direct electronic fund transfers from a vending agent to the supplier's bank account.

10.19 Class 19: Time_Provision process

The processes associated with providing date and time information to other functions for the control of time-based schedules. These include the generation, distribution and synchronization of timing signals and generally the management of timing functions in the system.

10.20 Class 20: System_Testing process

The processes associated with testing for the correct working of the system functions and processes.

10.21 Class 21: Information_Display process

The processes associated with displaying or viewing information within the system.

Examples are: reports for management purposes, notifications to customers or system operators and requests from customers.

10.22 Class 22: Information_Recording process

The processes associated with the recording of information and events within the system, including the generation, capturing and storage of the data elements.

10.23 Class 23: Data_Exchange process

The processes associated with the movement of data elements between entities within the system.

Examples are: uploading of transaction records from the POS to the CIS, transfer of credit from the POS to the meter by means of a token on a token carrier, downloading of customer records from the CIS to the POS, archiving and backup/restore.

10.24 Class 24: Security_Enforcement process

The processes associated with assuring the integrity of the system.

11 Generic Functions

See also clause 4 for a discussion on general concepts and clause 6 on generic functions employed by the generic payment metering system application process.

A function is in essence an encapsulated process with defined start and end states, input arguments, transformation function or logical operation and an end result. Functions may be simple or complex and will usually operate on data elements to move them within the system or transform them into different formats or to make logical decisions based on the results of such transformations or computations, which in turn direct the flow of processes. Functions are embodied in one or more devices or entities that may be distributed within a particular

system architecture and they may in turn call on the services of other functions during their execution or they may even invoke other processes. Functions may be implemented in software, electronic firmware or hardware and mechanical hardware. For example the function of the load switch is to interrupt or restore the supply to the customer's load circuit and the implementation may be a combination of firmware, electronic circuitry and mechanical parts to perform the switching function.

It should be noted that although these function classes indicate the singular for each class in the generic sense, actual implementations typically have several variant instances of functions that belong to the same generic class.

With reference to Clause 6 and Figure 3, the generic function classes are defined as follows.

Table 6 – Definition of generic function classes

Class	Function	Subclause
1	Supplier	11.1
2	Customer	11.2
3	Contract	11.3
4	Generation	11.4
5	Transmission	11.5
6	Distribution	11.6
7	Metering	11.7
8	Delivery	11.8
9	Accounting	11.9
10	Receipting	11.10
11	Settlement	11.11
12	Time	11.12
13	Test	11.13
14	Display	11.14
15	Recording	11.15
16	Data_Exchange	11.16
17	Security	11.17

11.1 Class 1: Supplier function

Capability of legally assuming responsibility for the supply and delivery of electrical energy to the Customer.

- Legal entity that enters into a contractual supply agreement with the Customer;
- Effects delivery of electrical energy to the Customer.

NOTE The supplier may optionally also have agreements with a generator company, a transmission company, a distribution company or a meter operator company. In the deregulated markets, the supplier may also be known as the retailer.

11.2 Class 2: Customer function

Capability of legally assuming responsibility for the payment of supplied and delivered electrical energy.

- Legal entity that enters into a contractual purchase agreement with the Supplier.
- Receives delivered electrical energy from the Supplier or his agent.

- Receives bills or statements (optional) from the Supplier or his agent.
- Makes payments for billed amounts due or for purchasing of pre-paid tokens.
- Receives receipts for payments made.

11.3 Class 3: Contract function

Capability of legal prosecution of the terms and conditions agreed between the Supplier and the Customer.

- Records the terms of the agreement entered into between the Supplier and the Customer.
- Legally defines and enforces the business rules and the control policies for the system.
- Serves as terms of reference for possible future law enforcement processes.
- Defines the operational attributes of the Accounting function.
- Defines the operational attributes of the Metering function.
- Defines the operational attributes of the Delivery function.
- Authorizes the Distribution function to connect the customer's installation to the distribution network.

NOTE In some cases the actual documents are maintained outside of the payment metering system, in which case only an agreement reference number is recorded for use inside the system.

11.4 Class 4: Generation function

Capability of generating electrical energy.

- Converts raw materials into electrical energy.
- Transfers the generated electrical energy into the transmission grid.
- Optionally has a contractual agreement with a transmission company and/or trades in the wholesale market.

NOTE 1 This technical report does not cover the Generation function in any detail, but some material is presented here for the sake of completeness and for possible future reference.

NOTE 2 In the context of the deregulated market, several generators may pool electrical energy into the grid at various time intervals. An independent entity collects measurements and arbitrates over the settlement of the accounts between several independent legal entities operating along the chain of supply from generation down to the point of delivery at the customer installation.

NOTE 3 There are instances of Generation functions that are integrated into payment metering systems. For example: certain payment metering systems currently employ an integrated solar energy generator, storage battery and pre-payment meter. In this case the generation, transmission, distribution, metering and delivery functions are all integrated into a single unit.

NOTE 4 The Generation function also contributes to other detrimental electro-magnetic disturbances that may be present at the metering and delivery points. For example: voltage regulation, load regulation, frequency regulation, harmonics, voltage dips and interruptions.

11.5 Class 5: Transmission function

Capability of transmitting electrical energy from the generator to the distribution network.

- Receives the generated electrical energy from the generator.
- Transmits the generated electrical energy from the generator to the distribution network;
- Transfers the transmitted electrical energy into the distribution network.
- Optionally has a contractual agreement with one or more generators.
- Optionally has a contractual agreement with one or more distributors.

NOTE 1 This technical report does not cover the Transmission function in any detail, but some material is presented here for completeness and for possible future reference.

NOTE 2 The transmission medium is generally referred to as the grid and transmission is typically done at high voltages to reduce energy losses over long distances.

NOTE 3 The grid also contributes to electro-magnetic disturbance that may be present at the metering and delivery points of the supply chain caused by events like high voltage switching, voltage and current surges induced by lightning and reflected load impedance changes. It is thus important to take cognisance of these characteristics when designing protection, withstand and performance specifications for equipment lower down in the supply chain, in particular metering and delivery equipment at the customer installation.

11.6 Class 6: Distribution function

Capability of distributing electrical energy from the transmission grid to the customer's installation.

- Receives the transmitted electrical energy from the transmission grid.
- Typically transforms it to appropriate voltage levels.
- Distributes it to the customer installation in a safe and efficient way.
- Receives authorisation to connect (or disconnect) the customer installation to the distribution network.
- Connects (or disconnects) the customer installation to the distribution network.
- Optionally creates the customer installation and installs the metering and delivery equipment.
- Optionally has a contractual agreement with the transmission company.

NOTE 1 The act of performing the connection (or disconnection) is a legal process and is distinctly different from the process of interruption or restoration of the supply to the customer's load in accordance with available credit in the Accounting function. See also Delivery function for more detail on the latter.

NOTE 2 The actual connection (or disconnection) is typically done outside the customer's premises in a junction box on the ground (for underground distribution networks) or on the top of a pole (for overhead distribution networks). The connection methods are subject to the relevant legal requirements and codes of practice that ensures the safety and technical performance of the installation.

NOTE 3 There may also be undesirable electro-magnetic disturbances that originate on the distribution network due to various design and operational factors. For example: voltage/load regulation, high neutral/earth impedance, lightning induced current and voltage surges, fault current protection and safety devices, electrical noise generated by certain customers' load equipment, harmonic distortion, voltage dips, brownouts and supply interruptions, etc. These are quality of supply factors that should be taken into consideration when specifying the requirements for the withstand capability and the performance of metering and delivery equipment.

11.7 Class 7: Metering function

Capability of measuring the quantity and optionally the quality of electrical energy delivered to the Customer.

- Receives and measures the electrical energy from the distribution network connected to the customer installation in accordance with relevant codes of practice for safety protection and equipment performance.
- Receives a metering configuration profile from the Contract function that determines the operational attributes of the Metering function.
- Makes the measurement information available for use by other functions.
- Transfers the metered electrical energy to the Delivery function.

An example of attributes for a metering configuration profile is:

- service type (electricity, water, gas, etc.);
- measurement types (frequency, voltage, current, phase angle, power factor, phase-unbalance, apparent power, active power, reactive power, apparent energy, active energy, reactive energy, etc);
- measurement accuracy class;
- measurement registers.

NOTE 1 Various methods of collecting meter readings are employed. For example: meter readers that visit the meter, remote automatic meter reading via communications infrastructure (telephone, radio networks, internet, etc) or direct wired connection to the Accounting function (integrated within the payment meter).

NOTE 2 In most currently used pre-payment meters, the Metering function and the Accounting function are integrated in a single unit, in which case the meter readings are fed directly (firmware or electronic) to the accounting registers.

NOTE 3 The Metering function implementations vary from being a separate device (such as a traditional Ferraris disk meter) to being fully integrated together with other functions (e.g. present style single-part pre-payment meter).

NOTE 4 Various metrological methods are employed. For example: electromechanical or static.

NOTE 5 In certain deregulated markets, the Supplier may outsource the Metering function to a 3rd party (typically termed the meter operator), in which case the 3rd party may own the metering equipment.

NOTE 6 In present payment metering systems, the quality of supply measurements may not be implemented as a billable attribute, but this may be a requirement for future systems.

NOTE 7 The metering equipment needs to have suitable protection against the electro-magnetic disturbances originating in the Generation, Transmission and Distribution functions.

11.8 Class 8: Delivery function

Capability of delivering metered electrical energy to the customer's load circuit and to regulate the quantity and/or availability in accordance with regulating control instructions from the Accounting function and any constraining rules.

- Regulates the amount of electrical energy delivered to the customer's load circuit in accordance with the available credit in the Accounting function.
- Receives a delivery configuration profile from the Contract function.
- Receives metered electrical energy from the Metering function.
- Provides a load interface for connection to the customer's load circuit.
- Delivers the electrical energy to the customer's load circuit.
- Optionally monitors the attribute values of other functions and may interrupt the supply in response to detected changes in accordance with the delivery configuration profile attributes.

An example of attributes for a delivery configuration profile is:

- service type (electricity, water, gas, etc.);
- constraining rules placed on interruption and restoration of the supply to the customer's load circuit; (Examples are: non-interrupt times, non-supply times, life-line supply on expiry of credit, power limiting if below certain average consumption level);
- detection control parameters (Examples are: overvoltage, undervoltage, voltage dips, voltage interruptions, power limits, voltage reverse polarity, reverse energy, phase unbalance, expiry of available credit, replenishment of available credit);
- control parameters for automatic interruption of supply to the load;
- control parameters for automatic restoration of supply to the load;
- control parameters for manual restoration of supply to the load;
- control parameters for safety protection (overcurrent limit, earth-leakage limit).

NOTE 1 This function is not to be confused with the connection of the customer installation to the distribution network, which is a different process (see 10.6, Connection_Authorization process class 6). See also Distribution function.

NOTE 2 Delivery equipment is typically part of the customer installation and the load interface terminal set is legally and technically the Point_Of_Delivery.

NOTE 3 Some payment meters have Delivery functions that offer safety protection features like overcurrent, earth-leakage and mains isolation. These functions are the subject of other relevant specifications.

NOTE 4 The load interface terminals may follow various standards like DIN, BS or other national standards.

NOTE 5 In some implementations, the payment meter may have an integrated power socket outlet, in which case there is no additional distribution board or house wiring installed at the premises.

NOTE 6 A load switch typically performs the function of supply interruption and restoration to the load.

NOTE 7 Some payment meters have additional switching elements that perform functions other than that of the load switch. These switching elements may be physically separate devices or may actually share the same elements of the load switch, in which case the same load switch performs several functions.

NOTE 8 Manual restoration requires the presence and intervention of the user. Examples are: manual insertion of a token carrier, entering a code, pushing a button or operating a lever on the user interface.

NOTE 9 Automatic restoration does not require the presence or intervention of the user. For example: recovery from an undervoltage condition or from a voltage interruption.

NOTE 10 In the case of a single-part payment meter, the Metering function and the Delivery function would be contained in the same physical unit. These two functions may alternatively be physically separated, in which case an interface exists between them. Such an instance would constitute a multi-part payment meter installation.

11.9 Class 9: Accounting function

Capability of keeping an account of the balance of charges due and payments made by the Customer.

- Accounts for the balance of charges for delivered electrical energy against payments made in accordance with the terms and conditions of the Contract function.
- Receives the accounting configuration profile from the Contract function.
- Receives meter readings from the Metering function.
- Calculates consumption charges due and decrements the available credit.
- Optionally levies auxiliary charges for additional services.
- Receives credit from the Receipting function.
- Optionally receives credit from other credit sources (like grants, emergency credit and lifeline credit).
- Calculates credit due and increments the available credit.
- Provides information on available credit for use by other functions.
- Optionally sends bills or credits to the customer.

An example of attributes for an accounting configuration profile is:

- service type (electricity, water, gas, etc.);
- accounting mode (currency-based, energy-based, pre-payment or credit mode);
- available credit (current balance of accumulated credit versus accumulated charges);
- credit registers (accumulated credits transacted per credit type);
- charge registers (accumulated charges transacted per charge type).

NOTE 1 Charges are either tariff charges (for consumption) in accordance with a schedule of tariff rates or auxiliary charges in accordance with a schedule of auxiliary charge rates.

NOTE 2 Tariff rates are either time-based (e.g. time-of-use tariffs) or consumption-based (e.g. block tariffs).

NOTE 3 Time-based auxiliary charge rates are applied according to a time schedule (transacted hourly, daily, weekly, monthly, etc).

NOTE 4 Consumption-based auxiliary charge rates are applied according to a schedule of consumption categories.

NOTE 5 Examples of auxiliary charges are: standing charges, network availability charges, connection fees, arrears amounts to be collected, interest charges, penalties, taxes, fixed costs or variable costs, etc.

NOTE 6 In the case of currency-based accounting, the tariff is applied on the charges side of the Accounting function. In this case, the tariff converts metered energy units into currency debit units.

NOTE 7 In the case of energy-based accounting, the tariff is applied on the credit side of the Accounting function. In this case the tariff converts payment amounts into energy-based credit.

NOTE 8 In certain cases, auxiliary charges may be programmed into the payment meter and the accounting register is then periodically decremented with the scheduled amounts.

NOTE 9 In other cases, a separate account for auxiliary charges is maintained in the database of the point of sale equipment and then linked to the customer record or to his meter record, so that the customer has to pay a portion or all of these charges before he/she can purchase a pre-paid electricity token.

NOTE 10 Examples of credit sources are: purchased token credit, payment credit, reserved credit, emergency credit, time-based credit for scheduled release, consumption-based credit for scheduled release.

11.10 Class 10: Receipting function

Capability of receiving payments from the Customer.

- Receives payments from the customer.
- Issues receipts to the customer for received payments.
- Transfers credit to the Accounting function in accordance with receipted payments.
- Transfers receipted payments to the Settlement function for transfer to the Supplier.

NOTE 1 Stringent revenue protection mechanisms are normally implemented around the Receipting function and intensive use is made of the services provided by the security function.

NOTE 2 Payments are typically in the form of cash, cheques, postal orders, credit card payments, debit card payments, direct bank deposits, standing or debit orders, money transfers, direct deposits or other standard electronic fund transfer instruments employed in the financial world.

NOTE 3 Normally, there would be some additional information required in the form of customer identification on a bill, or an account reference number or other relevant information regarding the pre-payment meter record held in the database of the point of sale equipment in order for it to generate a pre-paid token for the correct payment meter or to allocate the payment made to the correct customer account.

NOTE 4 Credit transfer transactions may be in the form of a pre-paid token or via a journal entry into a ledger. In present pre-payment systems the sale of pre-paid tokens is the major part of the activity of the Receipting function and is generally known in the industry as credit dispensing or token vending.

11.11 Class 11: Settlement function

Capability of transferring receipted payments to the Supplier.

- Receives payments transferred from the Receipting function.
- Settles with the Supplier.

NOTE 1 Settlement typically involves processes such as cashing up and depositing into the supplier's bank account.

NOTE 2 Stringent revenue protection mechanisms are normally implemented around this function and intensive use is made of the services provided by the Security function.

NOTE 3 Examples of supporting instruments used by the Settlements function are: bank deposit slips, bank statements and collection receipts from 3rd party banking agencies.

NOTE 4 This also serves as a convenient point for financial reconciliation with the Receipting function.

NOTE 5 In deregulated markets, there are also settlement and reconciliation requirements for the overall energy trading arrangements; these are not specifically addressed further in this document.

11.12 Class 12: Time function

Capability of keeping date and time information for use by other functions.

- Maintains date and time information.
- Provides date and time information to all other functions.
- Provides time reference signals.
- Optionally maintains a backup supply to sustain time information records.

NOTE 1 Examples of typical time information are: year, month of year, day of month, day of week, time of day, time-zone reference, daylight savings start and end dates.

NOTE 2 Examples of typical uses of the time information are: reference for controlling schedules in complex time of use tariffs and other time-based charges, date- and time-stamps for record entries, time-base for application process control like the microprocessor clock for sequencing of firmware micro code and timing out of expected events.

NOTE 3 Examples of time reference signals, which the Time function makes use of are: electronic oscillator circuits, reference frequency of the supply voltage, radio broadcast synchronization timing signals from terrestrial or satellite sources.

11.13 Class 13: Test function

Capability of testing for the correct working of functions and processes.

- Used as a means for evaluating the correct operation of system functions.
- Used as a means for directing the flow of a process according to the result of a test.

NOTE 1 Tests are initiated or terminated by events, either manually by the action of a system user or automatically during the execution of a program. For example: the press of a button, entering a code, or inserting a special action token.

NOTE 2 Examples of Test functions are the correct functioning of:

- indicators and display devices;
- the load switch;
- the token reading interface;
- the integrity of the memory recording registers;
- the meter Accounting function;
- the Data_Exchange functions;
- the Security functions;
- the Recording functions;
- the Metering function and of the system interfaces.

11.14 Class 14: Display function

Capability of displaying information to users.

- Provides an interface for communicating information to users of the system.
- Provides forms/screens for the capture of information from users of the system.

NOTE 1 Some information is permanently displayed, such as labels and markings on the user interface of equipment, while other information is transiently derived from recorded data elements.

NOTE 2 Events to initiate or terminate, the display process may be manually generated by a user like: a database query, the press of a button, entering a code, or inserting a special action token. Events may also be automatically generated, like a process state generating an indication of an alarm condition.

NOTE 3 Examples to illustrate the variety of such displayed information are: available credit in the accounting register on the meter display device, accumulated total register value on meter display device, tariff rate on meter display device, measured power in load on meter display device, consumption rate on LED indicator, status of incoming supply on neon indicator, state of the load switch on LED indicator or visible position of mechanical actuator lever, tamper status register on meter display device, printed meter serial number on front panel of meter, printed terminal cover markings, printed exception report on customer buying patterns, printed meter inspection list, graphical or textual screens on POS terminal, printed numeric token carrier, printed receipt, printed bill, printed summary of shift, sales and banking batches, banking deposit slips, bank statements, etc.

NOTE 4 Examples of typical display devices used in payment metering systems are: LED or neon indicators, LCD on meters and handheld devices, CRT on POS equipment, labels on devices, markings on user interfaces, paper printing devices, barcode printing devices.

11.15 Class 15: Recording function

Capability of keeping records of information.

- Maintains a record of the attributes of entities and of events that occur within the payment metering system.

NOTE 1 These include the initial capturing of information and subsequent additions or changes that are made over time.

NOTE 2 For examples of records that are generally used in payment metering systems see also Clause 12 on data elements.

11.16 Class 16: Data_Exchange function

Capability of moving data elements between entities.

- Moves data elements across interfaces between system entities using defined protocols.

NOTE 1 It essentially manifests as the functions or services employed in the application layer and the physical layer (plus possible intermediate layers) of a communications interface protocol (See also Clause 13 on system entities and interfaces).

NOTE 2 Examples of implementations of this function are: a token carrier may be manually transported by the customer from the POS to the Meter or automatically via a network connection, Transaction records are transferred from the POS to the CIS, customer and system information records are transferred from the CIS to the POS, database records are archived from the operational system onto a second off-line system or passively stored on removable storage mediums like CDROM, magnetic tape, magnetic disk, etc, database records are backed up onto removable medium or secondary storage systems for disaster recovery purposes.

11.17 Class 17: Security function

Capability of maintaining the integrity of data elements, functions and processes.

- Maintains the integrity of the system.

Some examples of security function attributes are given in Table 7 below.

Table 7 – Examples of security function attributes

Attribute	Context
Identification	Method of uniquely identifying an entity within the system (log-on name, account number, meter number, card number, record identifier, batch number, receipt number, personal ID number, street name and number, bank name and branch code, token identifier, etc.)
Authentication	Method of determining that the sender of a given piece of information is who it claims to be or represent (password, message authentication code, signature, biometric, private and public cryptographic keys)
Integrity	Method of determining that a given piece of information is true to the original (Cyclic_Redundancy_Code, parity check, etc.)
Non-repudiation	Method of ensuring that the sender of a given piece of information cannot deny having sent it (RSA signature, message sequencing)
Confidentiality	Rendering a private message unintelligible to an unauthorized reader (using encryption like DES, AES, RSA, proprietary algorithms, etc.)
Authorization	Giving approval to perform defined actions within the system (user registration, access rights assignment, free token issues, transaction reversals, access rights to records (read, write, modify), etc.)
Verification	Checking that a claimed activity had taken place or that a reported status is true (calibration accuracy, meter audit, cash register reconciliation, bank statement reconciliation, etc.)
Certification	Giving legal and traceable standing to the results of a verification process (metrology type certification, safety, code of practice, etc.)
Validation	Making new information valid (token generation, etc.)
Cancellation	Making currently valid information permanently invalid (token acceptance in meter, returned tokens, etc.)
Expiration	Making information valid for a given period of time only (cryptographic key expiry, tariff expiry, password expiry, vendor credit expiry, etc.)
Registration	Keeping a register of assigned security attributes of entities within the system (public cryptographic key registry, user registration)
Rights-assignment	Trusted responsibility for administering the assignment of security rights to other entities within the system (usually performed by the highest trusted officer in the user hierarchy)

Table 7*(continued)*

Attribute	Context
Supervision	A level of trust and authorized security rights to monitor and control activities of other entities within the system (for example: the person in charge of one or more cashiers and who might also do the banking)
Sealing	Limiting physical access to sensitive parts within the system in such a way that renders such intrusion obvious and detectable (meter terminal seals, physical protection of secure module for storage of crypto keys, a marked seal may also be the indicator of a certification)
Detection	Reporting of the fact when a security attribute of the system has been breached (broken meter seals, deviations in purchase pattern analysis, energy balancing)
Prosecution	Law enforcement processes applied to a perpetrator as a consequence of committing fraud or breaching unauthorized security attributes of the system

11.18 Function_Object

11.18.1 Function_Object definition

A Function_Object is an abstract notation of defining the attributes of a function.

Definition of a function object should state at least the following attributes.

Table 8 – Attributes of the Function_Object

Attributes	Context
Name	Name of the function object as a key attribute
Class	The generic classification number
Data_Elements	Data elements that are operated on
Methods	External interface to data elements or to services that may be invoked
Operation	What the function does or what its purpose is
Association	Other functions it calls on or processes it invokes

11.18.2 Function_Object example

An abbreviated example of a Real_Time_Clock function object is shown in the table below.

Table 9 – Example of a Real_Time_Clock function object

Attribute	Context
Name	Real_Time_Clock
Class	:= 12; belongs to the generic class of Time function
Data Elements	
Time	Local time: hours, minutes, seconds, hundredths
Date	Local date: year, month, day of month, day of week
Time_Zone	Deviation of local time to GMT in minutes
Daylight_Saving_Start	Date when local time shifts by the deviation
Daylight_Saving_End	Date when local time shifts back to normal
Daylight_Saving_Deviation	Deviation of daylight saving time in minutes
Daylight_Saving_Enabled	Enable or disable daylight saving function

Table 9 *(continued)*

Methods	
set_Date_Time()	Sets the date, time and time-zone parameters in the meter
get_Date_Time()	Returns the date, time and time-zone parameters in the meter
display_Date_Time	Displays the date, time and time-zone parameters on the meter display
set_Daylight_Savings()	Sets the start, end, deviation and enables parameters in the meter
get_Daylight_Savings()	Returns the start, end, deviation and enables parameters in the meter
display_Daylight_Savings	Displays the start, end, deviation and enables parameters on the meter display
Operation	
Date management	Maintains date information and makes it available to other functions
Time management	Maintains time information and makes it available to other functions
Time-zone management	Manages time adjustments to compensate for time-zones
Daylight savings management	Manages time adjustments to compensate for daylight savings requirements
Association	
Display function	Submits values to be displayed when invoked by the display_Date_Time and display_Daylight_Savings methods
Recording function	Submits values to be recorded when invoked by the set_Date_Time() and set_Daylight_Savings() methods
Data_Exchange function	Returns values to be exchanged when invoked by the get_Date_Time() and get_Daylight_Savings() methods

12 Data elements

See also Clause 4 for a discussion on general concepts.

Data elements are the instruments used to keep record of information on the status of the system and changes over time.

Definition of a Data_Object should state at least the following attributes.

Table 10 – Attributes of a Data_Object

Attribute	**Context**
Name	Name of the data object as a key attribute
Structure	Integer, num, char, string, etc
Context	Meaning of the data element within the application
Associations	Relational association with other data elements (foreign keys)
Access mode	Access control (read only, read and write)
Triggers	Association with a function that gets invoked when a data element gets changed

System entities embody data elements and they are thus distributed within the system to where they are required to fulfil their specific purpose. Some system entities may embody only a few data elements, while others may embody more. Where there is a large congregation of data elements such as in the CIS, it is normal practice for the data to be organized into more formal and manageable database structures.

Relational associations exist between data elements, thus implying logical context and making it possible to model the external workings of the payment metering system fairly accurately. For example: “User_name”, “Password” and “Receipting_function” are 3 data elements that are associated by logic in that a particular user with that name and password is authorized to perform the activities related to the Receipting function.

Data elements may be grouped into a record or a table of records where, in the case of a relational database, these tables are relationally associated or linked with each other and specifying the data elements in the record that are related to the data elements in the other table.

In a normalized database, a particular data element will be primarily recorded in only one record in the entire database and thereafter, it will be merely referenced from other tables that require to have a relational association with that particular data element. Such an object-oriented database design is highly desirable, because with careful consideration to the relational associations it can very effectively model the payment metering system and make the execution of the operational processes much simpler and easier to manage with a corresponding reduction in data errors.

In general, all entities in a payment metering system are secured by allocating unique reference identifiers to them and assigning access rights of read only, or read and write to the data elements associated with them for control purposes.

In a normalized database, the classification of data elements is most conveniently done by reference to the system entity, with which the data element is contextually associated. For example: in the “Customer_record” we would find Customer_Name, Customer_ID and Customer_Address, so these data elements would conveniently be classified under “Customer“.

As specific systems are defined, each system should publish its specific data elements and the attributes of each element.

Examples of records that are generally used in payment metering systems are shown in the following table.

Table 11 – Examples of records used in payment metering systems

Record name	Context
Agreement_record	Details of supplier/customer contractual relationship. This may be comprehensive or limited to an external reference number
Batch_record	Shift batches, sales batches, banking batches. For grouping of related records, summary information, for control and reporting purposes
Debt_record	Auxiliary debts that the customer may have and that has to be collected by the payment metering system
Fixed_Charges_record	Other fixed amounts that are periodically charged to the customer’s account, and which the payment metering system must collect on behalf of the supplier
POD_Tariff_Profile_record	Simple or complex tariff attributes that are linked to the supply agreement, and which is to be applied at the point of delivery
POS_Tariff_Profile_record	Simple or complex tariff attributes that are linked to the supply agreement, and which is to be applied at the point of sale
Tax_Profile_record	Profile of taxes that are applicable to the sale of the electricity at the time of purchase or the time of billing
Customer_record	Details of the customer. These may be comprehensive or limited to a reference number in an external customer information or financial system
Supplier_record	Details of the supplier. These may be comprehensive or limited to a reference number in an external customer information or financial system

Table 11 *(continued)*

Record name	Context
Location_record	Used for tracking of meter movement and linking of point of delivery records to a particular physical location or site
Point_Of_Delivery_record	Details and attributes of the installation characteristics regarding the point on the distribution network where the customer connects his load circuit
Meter_record	Details of the meter attributes
Readings_record	Readings received from the metering function
Resource_record	Details about the type of resource that is supplied by the supplier. This may be electricity, gas, water, heat, etc.
Bank_record	Details of the bank and account reference that is to be used in the banking process
Payment_record	Details of payments receipted by the receipting function
Transaction_record	Journal of transactions resulting from a purchase or a payment
Accounting_Register	Working register that keeps a balance of consumption versus payments
User_record	Register of users that are authorized to operate selective functions in the system
Security_Level_Profile_record	Register of access rights to selective system functions that may be linked to registered users
Station_record	Register of points within the system where an user may perform operations on the system. These are generally workstations and points of sale
System_Status_record	Attributes of the system that reflects the operational state of the system and that may be used for control and monitoring purposes
Audit_Log_record	Results of audits or other actions that are performed on the integrity of the system. These may be manually or automatically generated and performed
Data_Exchange_Log_record	Results of events or processes whose function it is to move data within the system. These entries may be manual or automatic
NOTE Each of these records normally contains further data elements, not listed here for the sake of simplicity.	

13 System entities and interfaces

See also Clause 4 for a discussion on general concepts and Clause 5 for generic entity model.

An entity specification should specify the embodied functions and the relevant interfaces.

The main system entities are: Customer_Information_System, Point_Of_Sale, Meter, Token and Users of the system. The interfaces between these entities allow data and information to be exchanged between them.

Examples of typical interfaces are:

- a payment meter user interface allows a user to interact with the payment meter. Elements of such an interface are typically: displays (LCD, LED, labels, markings), buttons and levers;
- a physical token carrier interface on the payment meter allows tokens to be manually transferred from the POS to the payment meter (keypad, magnetic card reader, memory key devices, etc);
- a virtual token carrier interface on the payment meter allows tokens to be directly transferred from the POS or CIS to the payment meter. (PLC modem, PSTN modem, GPRS modem, radio modem, LAN, WAN, Blue Tooth, etc).

An interface specification specifies an application layer protocol and a physical layer protocol, with possible intermediate layers.

The application layer specifies the functions or services it provides and the data elements (APDU) that are moved across the interface. See also 11.16, Data_Exchange function.

Other functional interfaces like the terminal arrangement for connection of the meter onto the distribution network is covered under the specification for the meter (see 13.7, Payment_Meter).

13.1 CIS: Customer_Information_System

The CIS records customer information and is the primary point in the system where such information is captured and maintained.

These systems may vary from small stand-alone database applications (CIS and POS functions integrated in one unit) to large enterprise financial systems.

CIS specifications should define the functions it provides, data elements it operates on and the interfaces it provides.

13.2 CIS_to_POS_Interface

This interface allows for the exchange of data between the CIS and the POS. Normally, customer data, financial data and system configuration data will be transferred from the CIS to the POS, while transaction data will be transferred from the POS to the CIS or to an accounting system.

Examples of application layer functions are shown in the following table.

Table 12 – Examples of application layer functions

Function	Context
Record_Addition	Adding a new record to the data base
Record_Deletion	Removing an existing record from the data base
Record_Modification	Replacing data in an existing record with new data
Record_Retrieval	Searching for existing records in the database
Record_Linking	Create an association between two records in a relational database

13.3 POS: Point_Of_Sale

A POS may operate from a local database (off-line) or from a remote database in an on-line client/server mode.

POS specifications should define:

- the functions;
- the data elements used;
- and interfaces.

For some systems employing virtual token carriers the POS operation and interfaces may differ from those for physical token carrier based systems.

Examples of POS functions are shown in Table 13 below.

Table 13 – Examples of POS functions

Function	Context
Arrears_Payments_Receipting	By conditional control of the purchase of tokens until a certain portion of arrears has been paid. Examples are: minimum monthly amount, fixed monthly amount or % of token value
Account_Payments_Receipting	Payment of billed account for post payment customers that are registered on the database
Miscellaneous_Payments_Receipting	Payment of items like TV license, dog license
Taxes_Receipting	For payments that contain a taxed portion
Fixed_Charges_Receipting	For payments towards fixed charges.
Pre-paid_Token_Sales	For pre-payment meters
Token_Replacements	For returned tokens that did not work correctly
Token_Re-issuing	Giving a token that had been issued previously
Token_Free_Issuing	Tokens with no charge to the customer
Token_Cancellation	Cancelling an un-used token
Transaction_Reversal	Reversing a transaction in the database records
User_Log_On_Off	Access control of a user
Start_End_Shift_Batch	Keeps a summary record of transactions and payments receipted for a particular shift
Start_End_Sales_Batch	Keeps a summary of one or more shift batches
Start_End_Banking_Batch	Keeps a summary of one or more sales batches, and which reflects the totals to be banked
Banking_Batch_Reconciliation	Reconciling bank statements with banking batches
Engineering_Tokens	Special tokens for configuring meters
Special_Actions	Similar to engineering tokens
Tariff_Configuration	Management of tariff control records
Tax_Configuration	Management of tax control records
Fixed_Charges_Configuration	Management of fixed charges control records
Security_Devices_Configuration	Management of items like encryption devices
User_and_Security_Configuration	Management of users and access rights

13.4 POS_to_Token_Carrier_Interface

This interface specifies how data is transferred from a point of sale onto a token carrier and also from a token carrier to a point of sale.

The interface specifies the application layer and physical layer in terms of the OSI reference model with possible intermediate layers.

Examples of application layer token types are shown in Table 14 below.

Table 14 – Examples of application layer token types

Function	Context
transfer_Credit	Transfer an amount of credit to the accounting function in the meter. Values are electricity, water, gas, time, currency
set_Register	Set a control register in the meter to a given value. Examples are: load power limit, tariff rate, phase unbalance, water factor, date, time
clear_Register	Clear the contents of a register in the meter. Examples are: credit register, total register, tamper status
read_Register	Instruct the meter to transfer the contents of an internal register in the meter back onto the token carrier (two way token carrier)
test_Load_Switch	Perform a pre-defined test in the meter. Examples are: display device, load switch, token reader
display_Tamper_Status	Display the contents of internal registers in the meter on the display device. Examples are: available credit, accumulated totals, tamper status, load power, tariff rate, water factor, software version
Customer messaging	Special messages and information to be transferred to the meter for displaying to the customer when the token is entered (see NOTE)
Returning alerts	Status information from the meter returning to the management system via the token carrier (see NOTE)

NOTE Customer messaging and returning alerts are specifically relevant in two-way token carrier systems.

Examples of application layer security functions are:

- token confidentiality by encryption/decryption, such as DES, 3DES, AES and RSA;
- token authentication by cryptographic digital signature of Tokens;
- token validation by the use of token identifiers and CRC;
- token cancellation by registration of token identifiers for later comparison or by erasure of data on the token carrier.

The token carrier is defined as the carrier medium in the physical layer.

Examples of typical physical layer interfaces are: paper printer, barcode printer, magnetic card writer, smart card writer, memory key writer, GSM modem, PSTN modem, PLC modem, radio modem, direct local connection, optical LED, etc.

13.5 Token_Carrier

Token data is typically carried as a modulated signal on a physical medium.

The Token_Carrier is defined as the carrier medium in the physical layer of the POS_to_Token_Carrier_Interface specification and in the Token_Carrier_to_Meter_Interface specification (see 13.4 and 13.6).

Token carriers are classified into physical token carriers and virtual token carriers, each of which may provide for one-way or two-way communications (see 13.6).

Physical token carrier examples are: printed numbers on paper, magnetic encoding on a magnetic card, printed bar coding on paper, electronic storage in memory devices such as smart cards and keys, audio messages dictated by interactive voice response equipment.

Virtual token carrier examples are: PLC modems, PSTN modems, GSM modems, radio modems, infrared optical coupling, LAN, WAN, direct local connection, etc.

13.6 Token_Carrier_to_Meter_Interface

The Token_Carrier_to_Meter_Interface function deals with all activities related to the reading of information from and also the writing of information to token carriers.

It defines an application layer and physical layer in terms of the OSI reference model with possible intermediate layers, while the token carrier is defined as the carrier medium in the physical layer.

13.6.1 Sub-classification of the Token_Carrier_to_Meter_Interface functions

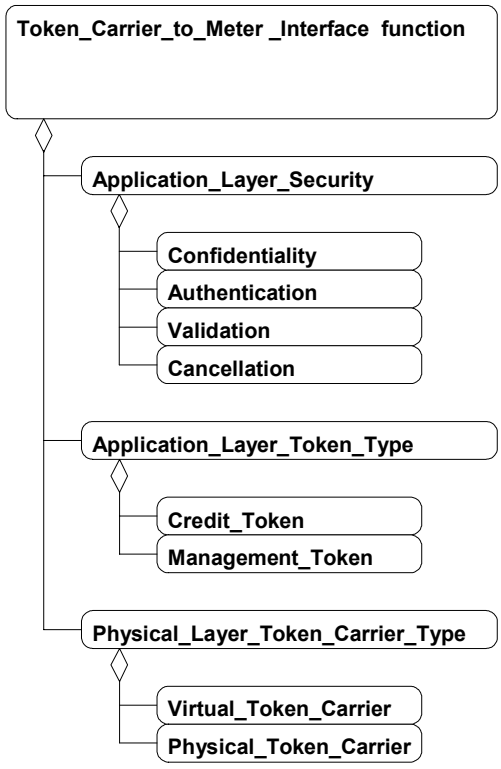


Figure 5 – Sub-classification of the Token_Carrier_to_Meter_Interface functions

See also Figure 6 below for a functional block diagram of a single-part payment meter installation.

The Token_Carrier_to_Meter_Interface functions are further sub-classified as shown in Figure 5 above and in Table 15 below.

Table 15 – Sub-classification of the Token_Carrier_to_Meter_Interface functions

Classified by function	Context
Application_Layer_Security	Functions used in the application layer that deal with securing the integrity of the token that is being transferred on the token carrier. These are further sub-classified into Confidentiality, Authentication, Validation and Cancellation functions
Confidentiality	Functions used in the application layer that deal with concealing and keeping the token information private in order to reduce the possibility of tampering and fraud. Examples are: using encryption algorithms such as DES, 3DES, AES and RSA with associated cryptographic keys
Authentication	Functions used in the application layer that deal with assuring that messages are authentic. Examples are: Successful decryption of token. Cryptographic signature of token data using secret shared keys or private/public key infrastructure
Validation	Functions used in the application layer that deal with assuring that tokens are valid. Examples are: By comparing token identifiers with those previously registered in the payment meter. CRC Checksum calculation on token data. Checking of manufacturer codes contained in tokens for manufacturer-specific meter functions
Cancellation	Functions used in the application layer that deal with assuring that tokens are only used once if so intended. Examples are: Token cancellation by erasure of magnetic information or by registering token identifiers in the payment meter for later comparison
Application_Layer_Token_Type	Functions used in the application layer that deal with the different types of tokens used in a payment meter. These are further sub-classified into Credit_Token and Management_Token functions
Credit_Token	Functions used in the application layer that deal with tokens that are intended for use in the transfer of credit from the point of sale to the payment meter. Examples are: purchased credit free issue credit, poverty grant credit
Management_Token	Functions used in the application layer that deal with tokens, which are intended for use in the transfer of instructions and information (other than credit) to the payment meter, by means of which the payment meter configuration may be managed remotely Examples are: initiation of test functions, initiation of display functions, setting of tariff and charge schedules, setting of other control parameters, retrieval of information from the payment meter
Physical_Layer_Token_Carrier_Type	Functions that deal with the different types of token carriers for the transfer of tokens to the payment meter. These are further sub-classified into Physical_Token_Carrier and Virtual_Token_Carrier functions
Physical_Token_Carrier	Functions that deal with physically transportable token carrier devices. Examples are: magnetic card readers, barcode readers, keypads, readers for smart cards memory key readers and other memory devices
Virtual_Token_Carrier	Functions that deal with all token carriers other than physical token carriers. These include all the OSI layers of local and remote connection communications protocols. Examples are: PSTN modem, ISDN modem, GSM modem, radio modem, PLC modem, Infrared, direct local connection, LAN and WAN connections
NOTE A given payment meter may implement any one or more combinations of these functions.	

13.7 Payment_Meter

Payment meters should be specified in terms of the definitions for processes, functions, data elements and interfaces indicated in this technical report. This will cater for all possible variants of single- or multi-part installations. Numerous combinations and variations have already been implemented and new ones will follow in the future.

Payment meters should conform to the minimum relevant functional requirements for payment meters given in IEC 62055-31.

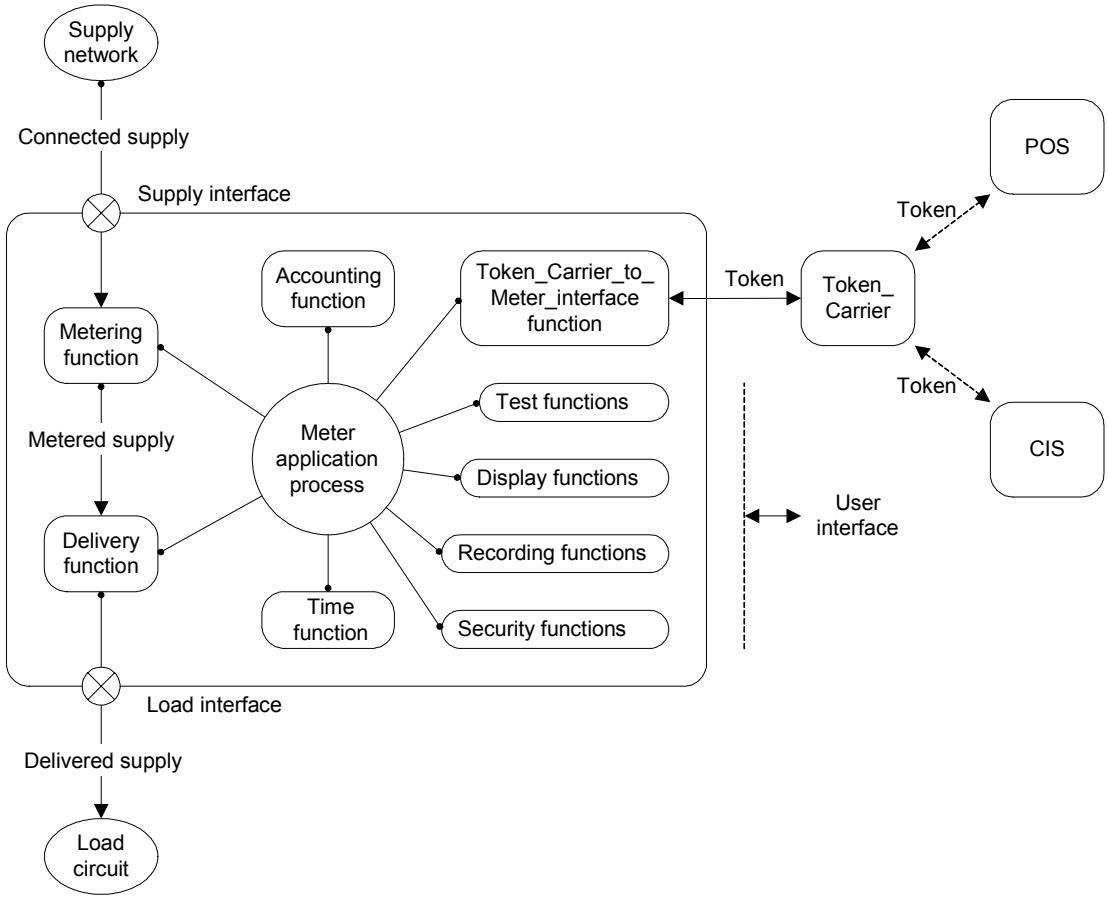


Figure 6 – Functional block diagram of a single-part payment meter installation

For ease of reference a functional block diagram of a single-part payment meter installation is given in Figure 6, indicating the core functions (see 13.7.1 to 13.7.5) and the support functions (not discussed in further detail).

13.7.1 Payment meter core functions and application process

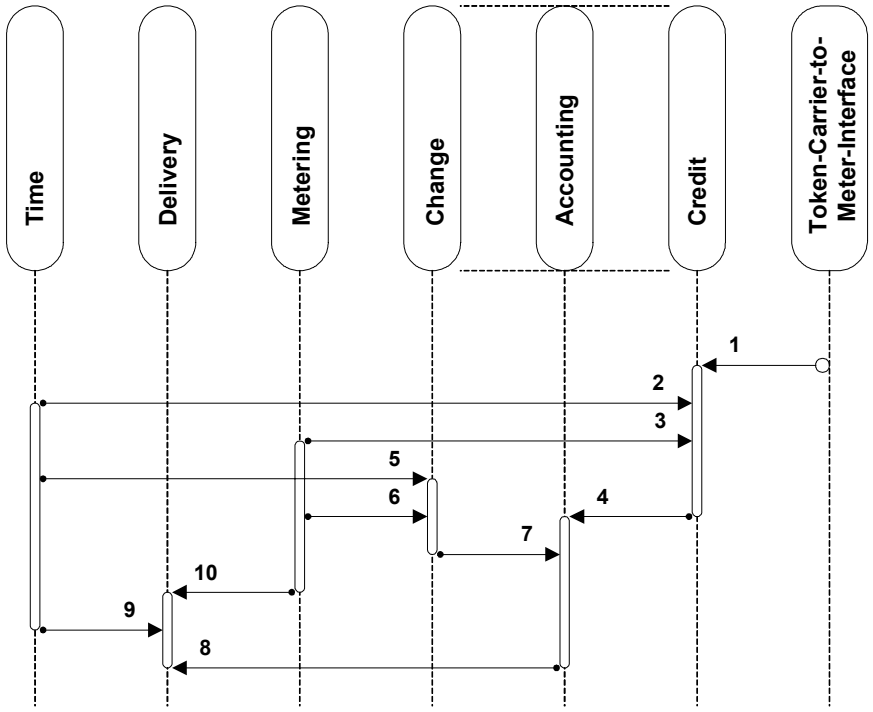


Figure 7 – Payment meter core functions and application process

It must be noted that a particular component in a payment meter may embody one or more of these functions and conversely a particular function may be deployed in a combination of components. There is, therefore, no specific rule to describe the relationship between a function and an object, which may be: one to one, one to many or many to one.

Functions are linked together by processes in order to achieve a particular result. A particular macro process may even be comprised of smaller processes or a mix of smaller processes and functions.

From this perspective the diagram in Figure 7 depicts the core functions and essentially indicates the core processes that are active in a payment meter. The subclauses following give more details on each of these function classes.

The Charge function and the Credit function are shown in Figure 7 as being separated for the sake of clarity, whereas they are actually sub-class functions of the Accounting function.

With reference to Figure 7, the generic payment meter application process thus employs the generic processes 1 to 10 as shown in Table16 below.

Table 16 – Generic processes employed by the payment meter application process

1	Calculation of token credit; any credit that is transferred to the payment meter by means of a Token_Carrier. Example: pre-paid token purchased at vending machine
2	Calculation of time-based credit; time information is required to regulate the scheduled release of time-based credit. Example: social credit grant of free basic electricity to the value of 50 kWh per month
3	Calculation of consumption-based credit; consumption information is required to regulate the scheduled release of consumption-based credit. Example: free basic electricity grant, but only if average monthly consumption is below 300 kWh
4	Transacting of total credit value; total sum of time-based, consumption-based and token credits to be added to the available credit at any particular instance of time. Example: purchased token plus any social credit grant portion
5	Calculation of time-based charges; time information is required to regulate the scheduled release of time-based charges and tariff rates. Example: monthly standing charge.
6	Calculation of consumption-based charges; consumption information is required to regulate the scheduled release of consumption-based auxiliary charges and to calculate charges for actual consumption. Example: tax on kWh consumed
7	Transacting of total charge value; total sum of time-based and consumption-based charges to be deducted from the available credit at any particular instance of time. Example: consumption plus tax plus standing charge
8	Regulating the supply of electrical energy in accordance with available credit; available credit information is required, according to which the supply to the consumer is interrupted or restored. Example: interrupt on expiry of available credit
9	Regulating the supply of electrical energy in accordance with time-based constraints; time information is required to regulate the scheduled constraints that are placed on the interruption or restoration of supply to the consumer. Example: non-interrupt at night during winter
10	Regulating the supply of electrical energy in accordance with consumption-based constraints; consumption information is required to regulate the scheduled constraints that are placed on the interruption or restoration of supply to the consumer. Example: non-interruption while below lifeline power limit

13.7.2 Sub-classification of the Accounting functions

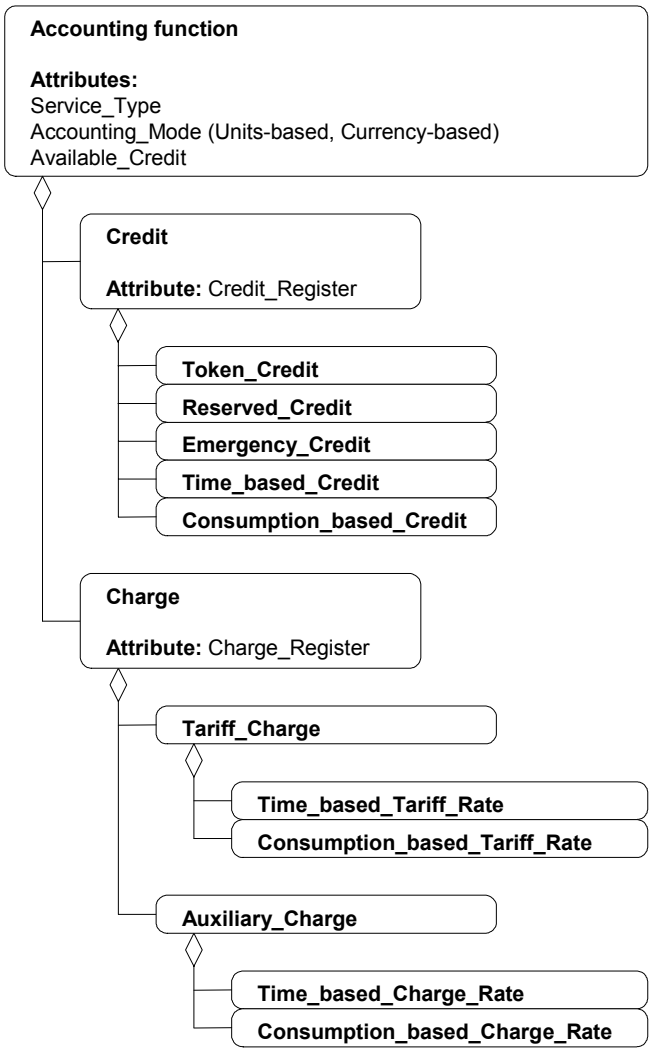


Figure 8 – Sub-classification of the Accounting functions

The Accounting function maintains a current balance of all credit and charge transactions performed in the payment meter. These activities together constitute the Meter Accounting Process.

The Accounting function is sub-classified as shown in Table 17 below.

Table 17 – Sub-classification of the Accounting functions

Classified by function	Context
Credit	Accounting functions that deal with the calculation and transacting of various types of credit by the Meter Accounting Process. These functions are further sub-classified into Token_Credit, Reserved_Credit, Emergency_Credit, Emergency_Credit, Time_based_Credit and Consumption_based_Credit functions
Token_Credit	Accounting functions that deal with the calculation and transacting of credit that is transferred to the payment meter in the form of Credit Tokens. Examples are: purchased credit, free issue credit and token replacement credit
Reserved_Credit	Accounting functions that deal with the calculation and transacting of credit that is held in reserve, which is released under specified conditions. In some instances, reserve credit is left on the token carrier for later release. One use of this feature is to ensure that consumers budget some reserve for use at night or during winter
Emergency_Credit	Accounting functions that deal with the calculation and transacting of credit that is released only under emergency situations. Usually the amount of emergency credit used is recovered from subsequent purchased credit token
Time_based_Credit	Accounting functions that deal with the calculation and transacting of credit that is released on a scheduled time basis. Examples of these are: indigent (poverty or social) grant of credit that is made available on a monthly basis, for example: 50 kWh per month
Consumption_based_Credit	Accounting functions that deal with the calculation and transacting of credit that is released on the basis of a schedule of consumption levels. Examples of these are: indigent grant of credit that is made available, as long as the consumer's monthly consumption is below 300 kWh
Charge	Accounting functions that deal with the calculation and transacting of various types of charges to the Meter Accounting Process. These functions are further sub-classified into Tariff_Charge and Auxiliary_Charge functions
Tariff_Charge	Accounting functions that deal with the calculation and transacting of charges for actual consumption of electrical energy by the consumer in accordance with a schedule of tariff rates. These functions are further sub-classified into Time_based_Tariff_Rate and Consumption_based_Tariff_Rate functions
Time_based_Tariff_Rate	Accounting functions that deal with the calculation and transacting of charges for actual consumption in accordance with a schedule of tariff rates related to the actual time of consumption. Examples are: Time Of Use Tariffs and hourly Demand Tariffs.
Consumption_based_Tariff_Rate	Accounting functions that deal with the calculation and transacting of charges for actual consumption in accordance with a schedule of tariff rates related to the level of consumption in a given period. Examples are: Block Tariffs and Block Demand Tariffs
Auxiliary_Charge	Accounting functions that deal with the calculation and transacting of charges, other than Tariff Charges. Auxiliary Charge functions are only applicable to currency-based accounting. These functions are further sub-classified into Time_based_Charge_Rate and Consumption_based_Charge_Rate functions
Time_based_Charge_Rate	Accounting functions that deal with the calculation and transacting of auxiliary charges in accordance with a schedule of charge rates related to date and time. Examples are: Debt recovery and Standing Charges, which may be transacted on an hourly, daily, weekly or monthly basis
Consumption_based_Charge_Rate	Accounting functions that deal with the calculation and transacting of auxiliary charges in accordance with a schedule of charge rates related to the level of consumption in a given period. Examples are: Standing Charge, which is applicable only for consumers that are consuming above 100 kWh per month, or a Tax Charge, which is not applicable to consumers while they are consuming below 100 kWh per month
NOTE 1 A payment meter may implement any one or more combinations of these functions. NOTE 2 It is common practice to combine consumption-based and time-based functions.	

The main attributes of the above functions are given in Table 18 below.

Table 18 – Main attributes of the Accounting functions

Attribute	Context
Service_Type	Determines which service type is being accounted for (electricity, water, gas, heat, time)
Accounting_Mode	Determines whether Accounting function transactions are currency-based or units-based
Available_Credit	The current balance of all the historical credits and charges transacted by the Meter Accounting Process over a given period of time, including any pending credits or charges
Credit_Register	Each of the Credit functions maintains a register of incurred and transacted credits in accordance with the particular instance and the type of the Credit function
Charge_Register	Each of the Charge functions maintains a register of incurred and transacted charges in accordance with the particular instance and the type of the Charge function. For example: a multi-rate tariff would have a register for each rate, which accumulates charges per rate per month

13.7.3 Sub-classification of the Metering functions

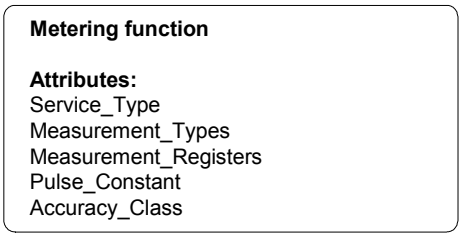


Figure 9 – Sub-classification of the Metering functions

The Metering function primarily deals with the measurement of the quantity of delivered electrical energy to the consumer. These measurements are made available for use by other functions in the payment meter.

The main attributes of Metering functions are given in Table 19 below.

Table 19 – Main attributes of the Metering functions

Attribute	Context
Service_Type	Determines which service type is being metered (electricity, water, gas, heat, time)
Measurement_Types	Defines the types of measurements that are performed by the particular function. Examples of measurement types are: frequency, voltage, current, phase angle, power factor, phase unbalance, apparent power, active power, reactive power, apparent energy, active energy, reactive energy
Measurement_Registers	Registers the quantities that are being measured in accordance with each particular type of measurement. Some measurements are instantaneous values and others are cumulative values. Examples of instantaneous values are: frequency, voltage and current. Examples of cumulative values are: apparent energy, active energy and reactive energy

Table 19 *(continued)*

Attribute	Context
Pulse_Constant	Defines the value of each output pulse on the user interface if provided by the function. For example: 1000 pulses per kWh
Accuracy_Class	Defines the accuracy standard that the metering function purports to meet. Examples are: class 2, class 1 and class 0,5

NOTE There is no need for sub-classification of the Metering function.

13.7.4 Sub-classification of the Delivery functions

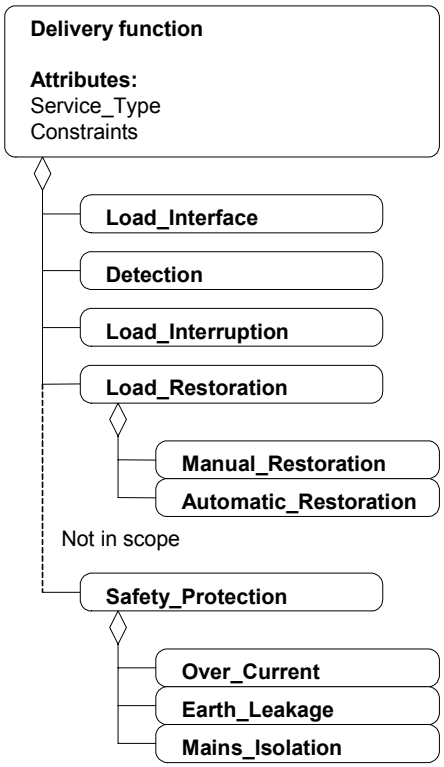


Figure 10 – Sub-classification of the Delivery functions

The Delivery function primarily deals with the functions related to the delivery of electrical energy to the consumer's load circuit. It also monitors the status of the attributes of other functions, in response to which it interrupts or restores the supply to the consumer's load.

Table 20 – Sub-classification of the Delivery functions

Classified by function	Context
Load_Interface	Delivery functions that enable the consumer's load circuit to be connected to the payment meter. Examples are: Directly wired connection to load-side terminals of the payment meter, an integral socket outlet built into the payment meter into which the consumer directly plugs his load, connection to the load-side terminals of an external load switch (single- or poly-phase) controlled by a low-current relay in the payment meter
Detection	Delivery functions that monitor and detect changes in the state of the attributes of other functions, in response to which it will interrupt or restore the load. For example: detection of: overvoltage, undervoltage, voltage dips, voltage interruptions, power limit, voltage reverse polarity, reverse energy, phase unbalance, expiry of available credit, replenishment of available credit
Load_Interruption	Delivery functions that deal with the interruption of the supply to the load in accordance with a defined set of rules that are linked to the detection functions. For example: Interrupt on detection of undervoltage, interrupt on detection of available credit expiry and interrupt on detection of power limit
Load_Restoration	Delivery functions that deal with the restoration of the supply to the load in accordance with a defined set of rules that are linked to the detection functions. A particular load switch could possibly have both automatic and manual restoration functions, where automatic restoration is programmed to apply only to selective Detection functions and others to manual restoration. For example: Automatic restoration when undervoltage conditions return to normal, but manual restoration after interruption due to power limit detection. These functions are further sub-classified into Automatic_Restoration and Manual_Restoration functions
Automatic_Restoration	Delivery functions that deal with the automatic restoration of the supply to the load, where the presence and intervention of a user is not required. Example: After recovery from an undervoltage condition
Manual_Restoration	Delivery functions that deal with the manual restoration of the supply to the load, where the presence and intervention of a user is required. Examples are: Replenishing available credit by means of a physical token carrier, entering of a code on the user interface, pushing of a key or a button or operating a lever on the user interface
Safety_Protection	These functions are outside of the scope of this technical report. These functions are further sub-classified into Over_Current, Earth_Leakage and Mains_Isolation functions.
Over_Current	These functions are outside of the scope of this technical report
Earth_Leakage	These functions are outside of the scope of this technical report
Mains_Isolation	These functions are outside of the scope of this technical report
NOTE 1 A payment meter may implement any one or more combinations of these functions. NOTE 2 The Safety_Protection functions are mentioned here for completeness, but are excluded from the scope of this technical report. These functions are the subjects of other relevant specifications.	

The main attributes of the Delivery functions are given in Table 21 below.

Table 21 – Main attributes of the Delivery functions

Attribute	Context
Service_Type	Determines which service type is being delivered (electricity, water, gas, heat, time)
Constraints	A set of rules that place constraints on the behaviour of Delivery functions. Constraints are either time-based or consumption-based. Examples are: At certain times of the day or night the load switch may not interrupt the load during winter season, or over weekends, or on public holidays. Conversely the supplier may contract with the customer that the supply will be interrupted during certain times of the day irrespective of whether there is available credit. Upon expiry of credit, then limit the load current to a 5 A lifeline supply, but only if the monthly average consumption is below 200 kWh, based on the average for the previous 6 months. In this case, the load switch may interrupt above 5 A, and automatically restore below 5 A load current

13.7.5 Sub-classification of the Time functions

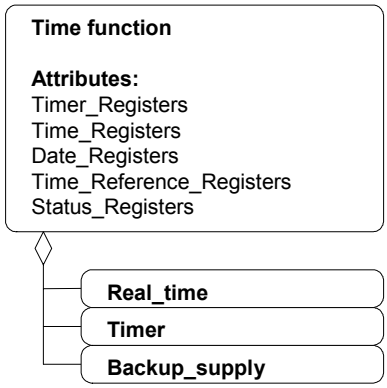


Figure 11 – Sub-classification of the Time functions

The Time function maintains date and time information and time reference information for use by other functions. It also maintains status of any backup supply used for time keeping during power outage of the distribution network.

Table 22 – Sub-classification of the Time functions

Classified by function	Context
Real_time	Time functions that maintain date and time information that is synchronized to actual date and time and where there is a backup supply. Examples are: date and time of day, time zone, and daylight savings
Timer	Time functions that account for the passage of time and provide time reference signals for the use of other functions. Examples are: clock signals for microprocessor, timing of operational life of meter, time-out of expected events and duration of displayed values
Backup_supply	Time functions that provide the means to maintain the time-keeping activity during periods when the payment meter is not connected to the mains supply voltage. Examples are: long-life batteries as primary cells, rechargeable batteries and super capacitors with their respective support circuitry
NOTE A payment meter may implement any one or more combinations of these functions.	

The main attributes of the above functions are given in Table 23 below.

Table 23 – Main attributes of the Time functions

Attribute	Context
Timer_Registers	Duration: days, hours, minutes, seconds, hundredths
Time_Registers	Time of day: hours, minutes, seconds, hundredths
Date_Registers	Date: year, month, day of month, day of week
Time_Reference_Registers	For example: time zone, daylight savings start date, end date and deviation
Status_Registers	For example: battery life remaining (days)

An example of a Real_Time_Clock function specification is given in 11.18.2.

Annex A
(informative)

Example of a requirements specification for an electricity payment metering system based on an existing system

A.1 Scope

This example is based on an existing STS one-way token carrier payment metering system employing energy/based credit tokens and serves to illustrate the use of IEC 62055-21 by a Utility for specifying the requirements of a payment metering system. Although there are several variants of one-way token carrier payment meters in existence, this example specifically excludes functions like overcurrent protection and earth-leakage protection.

It serves to illustrate a systematic approach to standardize and classify a complex system, incorporating many functions embodied in many entities.

NOTE 1 This annex does not include energy settlements aspects in deregulated markets.

NOTE 2 The examples of requirements given in this informative annex of this technical report necessarily involve the use of "shall". However, this does not imply that any part of this annex is normative in nature.

A.2 Definitions

In addition to the definitions given in IEC 62055-31 the following shall apply.

power limiting

function provided by pre-payment meters to limit the average power consumed to less than the value programmed in the meter with the relevant STS management token. The average power consumed is calculated over a number of measurements and is therefore not suitable to serve as input for an overcurrent protection feature.

A.3 Customer_Information_System

A.3.1 Supplier functions

It shall be possible to uniquely associate ownership of the entities (including data elements) in the system with a particular supplier.

A.3.2 Customer functions

The supply agreement processes shall fall outside the scope of this technical report, but the conclusion of such processes shall be the causal point for changes to be effected to customer records.

A.3.3 Contract functions

Connection authorization shall be managed outside of the payment metering system.

The accounting configuration profile for the POS shall be managed from the CIS and cater for a POS Tariff profile and an auxiliary charge profile in accordance with the supply agreement between the customer and the supplier.

The accounting configuration profile for the meter shall be fixed in the meter at the time of manufacture and shall not be required to be managed from the CIS.

The metering configuration profile shall be managed from the CIS.

The delivery configuration profile shall be managed from the CIS.

A.3.4 Recording functions

It shall be possible to create a record of attributes for each of the entities shown in the following table.

Table A.1 – Recording function records

Record	Context	Mandatory/ Optional
Customer_record	Personal and legal details of the customer	Mandatory
Supplier_record	Attributes of the supplier	Mandatory
Contract_record	Attributes of reference to the service agreement	Mandatory
Auxiliary_Charges_profile_ record	Attributes of charges that have to be levied at the point of sale.	Optional
POS_Tariff_Profile_record	Structure of tariff rates for the pre-paid token sales to be charged at the point of sale	Mandatory
Tax_Profile_record	Taxes that are to be levied on the various service and charge items	Mandatory
POD_record	Attributes of the point of delivery of the service	Mandatory
Location_record	Attributes of the physical location where the service is being delivered	Mandatory
Meter_record	Attributes of the pre-payment meter	Mandatory
Security_Profile_record	A record of access rights assigned to a particular security level	Mandatory
User_record	A record of attributes for a particular user	Mandatory
Bank_record	A record of attributes for a particular bank	Optional
Activity_Log_record	A record of actions that occurred within the system	Mandatory

It shall be possible to configure the relationship between these entities, and to add, edit or delete the attributes or the records.

It shall be possible to associate a contract record with a particular customer record and supplier record.

The recorded association between a customer, supplier and contract shall remain in place for life or until the supplier agrees to remove it.

It shall be possible to associate a POD record with a contract record, a POS tariff profile record and a location record.

It shall be possible to associate a meter record with a POS tariff profile record, a POD record and optionally with a location record.

Additions and changes to meter records shall take place upon appropriate notification from the supplier.

It shall be possible to associate an auxiliary charges profile record with a contract record and a tax profile record.

A record shall be created for each user and it shall be possible to add, edit and delete users from the system records.

Each user record shall be associated with a security profile record.

A security profile record shall maintain the attributes of access rights to system functions according to a defined security level.

A user activity log record shall be created for each action that takes place on the POS and shall capture at least the action, date, time and responsible user details.

The structure of the POS tariff profile shall be the subject of the supply contract according to the exact application requirements of the supplier.

It shall be possible to create different instances of POS tariff profile types, each having it's own structure.

The POS tariff profile record shall be optionally associated with a maximum power limit and a tariff index (see A.6.1).

If a POS is capable of receipting on behalf of more than one supplier, then the POS tariff profile record shall also be associated with the particular supplier record.

It shall be possible to change the tariff rate without having to define a new POS tariff profile and without losing definitions of previous tariff rates.

It shall be possible to load the new tariff rates ahead of time by associating it to a date of activation.

Records of previous tariff rates shall be kept on the system.

A date and time stamp shall be recorded in each system record and shall reflect the time of creation or modification of the record.

A.3.5 Display functions

It shall be possible to query and view the records using variable filter criteria.

On-screen contextually sensitive help menus shall be available for users where appropriate.

The language of choice for screen dialogs shall be the subject of the supply contract.

The requirements for printing of reports shall be the subject of the supply contract.

A.3.6 Data_Exchange functions

In the case where the CIS and the POS are physically separated, the data elements shall be transferred between the two entities via the CIS_to_POS_Interface.

The selection of data elements to be exchanged shall be determined by the management functionality requirements of the CIS and the POS.

Other interfaces and data exchange requirements such as to financial systems shall be the subject of the supply contract.

A.3.7 Security functions

Users shall log on and log off with a user name and password.

Users shall be able to change their passwords at any time.

Users shall be able to log off temporarily, while a replacement user logs on.

It shall be possible to create security levels, each having different security profiles of access to the system functions.

User access to system functions shall be constrained by an appropriately associated security level profile.

It shall be possible to audit the records of all activities and actions that took place on the CIS.

Supply voltage fluctuations or supply interruptions shall not interfere with the working of the system or cause unauthorized access to the system data or operating system.

The system shall not malfunction due to abnormal input conditions via the various interfaces including the keyboard for the user.

Validity and integrity checks shall be performed on all input data streams in order to minimize errors.

All entities (including data elements) shall have unique identifiers for audit and traceability purposes.

A.3.8 Time functions

A secure real-time clock with date and time keeping shall be provided for use in the CIS.

Setting or modifying of time and date registers in the real-time clock shall not be protected by the appropriate security level assignment to the particular user.

A.3.9 Test functions

Routine diagnostic test programs shall be provided to assist in validation of the system integrity. These may run automatically in the background or be initiated by the user.

A.3.10 Data elements

An example of a meter record is given in Table A.2 below.

Table A.2 – Example of Meter_record attributes

Attributes	Context
Meter_No	Unique reference number for this meter
Meter_Type	Pre-payment, credit, etc.
Manufacturer_Code	STS defined manufacturer code
Token_Type	STS defined token type (numeric, magnetic card, etc.)
Algorithm	STS defined encryption algorithm used in the meter
Supply_Group_Code	STS defined supply group code associated with this meter
Max_Power_Limit	STS defined maximum power limit set in the meter
Tariff_Index	STS defines tariff index associated with this meter
Tariff_ID	Tariff profile associated with this meter
Location_ID	Reference to the physical location of this meter
POD_ID	Reference to the point of delivery where this meter is installed
Supplier_ID	Reference to the supplier to whom this meter belongs
Responsible_User_ID	The user that was logged on when this record was created or modified
Time_Stamp	The date and time when this record was created or modified

The dimensional attributes of the fields are not shown as some elements are defined elsewhere and others are to be appropriate to the requirements of the application.

A.4 CIS_to_POS_Interface

A.4.1 Application layer services

The data exchange process shall be scheduled for automatic execution, but it shall also be possible to initiate the process manually.

The following records shall be periodically downloaded from the CIS to the POS.

Table A.3 – Records to be downloaded from the CIS to the POS

Records	Context	Mandatory/ Optional
Customer_record	Personal and legal details of the customer	Mandatory
Supplier_record	Attributes of the supplier.	Mandatory
Contract_record	Attributes of reference to the service agreement	Mandatory
Auxiliary_Charges_Profile_ record	Attributes of charges that have to be levied at the point of sale	Optional
POS_Tariff_Profile_record	Structure of tariff rates for the pre-paid token sales to be charged at the point of sale	Mandatory
Tax_Profile_record	Taxes that are to be levied on the various service and charge items	Mandatory
POD_record	Attributes of the point of delivery of the service	Mandatory
Location_record	Attributes of the physical location where the service is being delivered	Mandatory
Meter_record	Attributes of the pre-payment meter	Mandatory
Security_Profile_record	A record of access rights assigned to a particular security level	Mandatory
User_record	A record of attributes for a particular user	Mandatory
Bank_record	A record of attributes for a particular bank	Optional

The CIS shall keep these data elements up to date in the POS.

It shall be possible to add, replace, remove and modify records at the POS by means of this interface.

The following records shall be periodically uploaded from the POS to the CIS.

Table A.4 – Records to be uploaded from the POS to the CIS

Records	Context	Mandatory/ Optional
Transaction_record	A record of attributes for a particular transaction according to type	Mandatory
Payment_record	A record of attributes for a particular payment receipted according to type	Mandatory
Shift_Batch_record	A summary of transaction and payment records for a particular shift batch	Mandatory
Sales_Batch_record	A summary of shift batch records for a particular sales batch	Optional
Banking_Batch_record	A summary of sales batch records for a particular banking batch	Mandatory
Station_record	A record of attributes for a POS connected to a database	Optional
Station_Group_record	A record of attributes for one or more POS or stations connected to a database	Optional
Activity_Log_record	A record of actions that occurred within the system	Mandatory
Security_Profile_record	A record of access rights assigned to a particular security level	Mandatory
User_record	A record of attributes for a particular user	Mandatory

The POS shall keep these data elements up to date in the CIS.

It shall be possible to add, replace, remove and modify records at the CIS by means of this interface.

A.4.2 Network and physical layer

Connectivity between CIS and POS shall be possible using industry standard network services, protocols and devices.

Some examples are given below:

- landline modem on leased line or PSTN;
- GSM modem;
- ISDN modem;
- radio modem on X.25 protocol;
- digi-net modem on X.25 protocol;
- local area network and wide area network;
- X.25, TCP/IP, HTML, XML, RAS, C/S protocols;
- removable media like diskette, zip drive, flash RAM.

A.5 Point of sale

As a minimum requirement, the POS shall provide the functions defined below. Optional aspects are appropriately indicated.

A.5.1 POS_Accounting function

The POS tariff profile shall be managed by the CIS and be downloaded via the data exchange function.

This POS tariff is only applicable to the sale of pre-paid tokens.

Rounding quantities during tariff calculations shall be optionally recorded to assist with audit and reconciliation processes.

POS auxiliary charges profile shall be managed by the CIS and be downloaded via the data exchange function.

POS auxiliary charge profile shall include taxes, but debt and fixed charges shall be optional.

Credit transfer to the meter accounting function shall be via credit tokens (see POS_to_Token_Carrier_Interface).

The principle accounts for auxiliary charges and account payments shall be kept on the financial system and temporary accounts may optionally be kept on the POS or the CIS. Transaction records will thus be exported and new balances will be imported on a daily basis.

A.5.2 Receipting function

A banking batch shall be opened before an optional sales batch can be opened.

An optional sales batch shall be opened before a shift batch can be opened.

A shift batch shall be opened before any receipting can take place.

It shall optionally be possible to block the sale of pre-paid tokens to a particular customer in terms of the conditions set in the relevant auxiliary charges profile.

When a customer wants to purchase a pre-paid token, it shall be possible to assist the process of identification of the relevant meter by the following methods:

- the customer may quote the meter number;
- the customer may quote his personal details;
- the customer may quote his location details;
- the customer may quote his contract details;
- the customer may quote his POD details;
- the customer may present his meter identification card;
- the customer may present a previously purchased token.

It shall be possible to vend multiple tokens within a single receipting cycle.

It shall be possible to verify the validity and authenticity of any generated token.

It shall be possible to reprint a previously generated token. A system configuration attribute per token carrier type shall control whether a reprint action is allowed or not.

It shall be possible to cancel a previously generated token. Rules for control shall be implemented by management policy and enforced by security profile.

It shall be possible to receipt the following payment types.

Table A.5 – Payment types

Item	Payment type	Example	Context	Mandatory/ Optional
1	Cash	Notes and coins	Bankable hard currency	Mandatory
2	Cheque	Bank cheques	Bankable cheques	Mandatory
3	Postal order		Postal payments	Optional
4	EFT	Credit Card	From transaction switch	Optional
5	EFT	Debit Card	From transaction switch	Optional
6	EFT	Stop order	From bank statement	Optional
7	EFT	Debit order	From bank statement	Optional

It shall be possible to perform the following transaction types.

Table A.6 – Transaction types

Item	Transaction type	Context	Mandatory/ Optional
1	Electricity pre-paid sale	Electricity pre-paid token sale	Mandatory
2	Electricity pre-paid free issue	Electricity pre-paid token issued free of charge	Mandatory
3	Electricity pre-paid replacement	To transfer a credit balance from a faulty meter to the replacement meter	Mandatory
4	Electricity pre-paid reversal	Electricity pre-paid token sale reversal	Mandatory
5	Electricity pre-paid BSST	Electricity pre-paid token issued under the *Basic Support Services Tariff*	Mandatory
6	Tax collection	Tax portion of any taxable transaction	Mandatory
7	Tax reversal	Reversal of a tax transaction	Mandatory
8	Debt collection	Collection of debt loaded on the customer's account	Optional
9	Debt reversal	Reversal of debt collection transaction	Optional
10	Fixed charges collection	Collection of fixed charges loaded on the customer's account	Optional
11	Fixed charges reversal	Reversal of fixed charges collection transaction	Optional
12	Service payment collection	Payments on a billed account	Optional
13	Service payment reversal	Reversal of payments on billed account	Optional
14	Miscellaneous collection	Payments on non-billed items like fines, etc.	Optional
15	Miscellaneous reversal	Reversal of payments on non-billed items	Optional
16	Journal reconciliation	System journal entry for adjustments after reconciliation of transactions on offline POS terminals	Mandatory

The POS token vending capability shall be classified as follows:

Table A.7 – Classification of POS token vending capability

Class	Capability	Context	Mandatory/ Optional
V	STS Vending	Class 0 credit transfer tokens	Mandatory
E	STS Engineering	Class 1 and Class 2 tokens	Optional
K	STS Key management	Class 2 key change tokens, management of cryptographic keys	Optional

A transaction-itemised receipt shall be printed and issued to the customer for each payment receipted.

A.5.3 Settlement function

A banking batch shall be opened before a sales batch or a shift batch can be opened.

A banking batch shall be closed when a bank deposit is to be made.

It shall not be possible to close a banking batch unless the associated sales and shift batches are closed.

A.5.4 Recording functions

A date and time stamp shall be recorded in each system record and shall reflect the time of creation or modification of the record.

A different transaction record shall be created for each transaction type.

One or more transaction records shall be associated with a payment record and with a shift batch record.

A payment record shall be created for each payment type that gets receipted.

One or more payment records shall be associated with a shift batch record.

A shift batch record shall contain a summary of transactions and payments that occurred during a particular shift.

One or more shift batch records shall be associated with a user and with an optional sales batch record.

When a user logs off temporarily without closing his shift, the replacement user shall be associated with his own shift batch.

An optional sales batch record shall contain a summary of transactions and payments that occurred during one or more shifts.

One or more optional sales batch records shall be associated with a banking batch record and optionally with a station record.

A banking batch record shall maintain a summary of transactions and payments that occurred during one or more sales batches.

One or more banking batch records shall be associated with an optional bank record and with an optional station group record.

Rounding errors may be optionally recorded to aid reconciliation processes.

An optional station record shall maintain detail of the POS attributes and one or more station records shall be associated with an optional station group record.

A record shall be created for each user and it shall be possible to add, edit and delete users from the system records.

Each user shall be associated with a security profile record.

A security profile record shall maintain the attributes of access rights to system functions according to a defined security level.

A user activity log record shall be created for each action that takes place on the POS and capturing at least the action, date, time and responsible user details.

A.5.5 Display functions

Summary reports shall be printed when closing a shift batch, sales batch and banking batch.

It shall be possible to query and view the shift, sales and banking batch records with variable filter criteria and sorted by transaction type and payment type.

A transaction-itemised receipt shall be printed and issued to the customer for each payment receipted.

On-screen contextually sensitive help menus shall be available for users where appropriate.

The language of choice for screen dialogs shall be the subject of the supply contract.

The requirements for printing of additional reports shall be the subject of the supply contract.

A.5.6 Data_Exchange functions

In the case where the CIS and the POS are physically separated, the exchange of data elements shall take place via the CIS_to_POS_Interface.

The selection of data elements to be exchanged shall be determined by the management functionality requirements of the CIS and the POS.

Data exchange between the POS and the meter shall take place via the POS_to_Token_Carrier_Interface and the Token_Carrier_to_Meter_Interface.

A.5.7 Security functions

Users shall log on and log off with a user name and password.

Users shall be able to change their passwords at any time.

Users shall be able to log off temporarily, while a replacement user logs on.

It shall be possible to create security levels, each having different security profiles of access to the system functions.

User access to system functions shall be constrained by an appropriately associated security level profile.

It shall be possible to audit the logging records of all activities and actions that took place on the POS.

It shall be possible to reconcile the payment records, transaction records, shift batch records, sales batch records and banking batch records at any time before or after the batches have been closed.

It shall not be possible to modify any of the transaction, payment, shift batch, sales batch or banking batch records. Any adjustments shall be made by an appropriate transaction journal record entry.

All processes that operate on these records shall conform to the General Audit and Accounting Practice rules.

An optional system function may be implemented that limits the total bankable amount that the POS may receipt before a banking process is enforced. The supplier shall periodically reset the limit in response to a confirmation of bank statement reconciliation.

Supply voltage fluctuations or supply interruptions shall not interfere with the working of the system or cause unauthorized access to the system data or operating system.

The system shall not malfunction due to abnormal input conditions via the various interfaces including the keyboard for the user.

Validity and integrity checks shall be performed on all input data streams in order to minimize errors.

It shall not be possible to generate a token without creating a corresponding transaction record.

It shall be possible to query and list customer records that have purchased less than a certain amount in a given period.

All entities (including data elements) shall have unique identifiers for audit and traceability purposes.

A.5.8 Time functions

An accurate and secure calendar-clock shall be maintained for the purposes of deriving the Token_Identifier (see also A.6.1).

Setting or modifying of time and date registers in the real-time clock shall not be protected by the appropriate security level assignment to the particular user.

A.5.9 Test functions

Routine diagnostic test programs shall be provided to assist in validation of the system integrity. These may run automatically in the background or be initiated by the user.

A.5.10 Data elements

The following data elements shall be recorded in the system.

Table A.8 – Data elements to be recorded

Data element	Context	Mandatory/optional
Transaction_record	A record of attributes for a particular transaction according to type	Mandatory
Payment_record	A record of attributes for a particular payment receipted according to type	Mandatory
Shift_Batch_record	A summary of transaction and payment records for a particular shift batch	Mandatory
Sales_Batch_record	A summary of shift batch records for a particular sales batch	Optional
Banking_Batch_record	A summary of sales batch records for a particular banking batch	Mandatory
Station_record	A record of attributes for a POS connected to a database	Optional
Station_Group_record	A record of attributes for one or more POS or stations connected to a database	Optional
Bank_record	A record of attributes for a particular bank	Optional
Activity_Log_record	A record of actions that occurred within the system	Mandatory
Security_Profile_record	A record of access rights assigned to a particular security level	Mandatory
User_record	A record of attributes for a particular user	Mandatory
POS_Tariff_Profile_record	These are managed by and down loaded from the CIS	Mandatory
Auxiliary_Charges_profile_ record	These are managed by and down loaded from the CIS	Optional
Tax_Profile_record	These are managed by and down loaded from the CIS	Mandatory
Meter_record	These are managed by and down loaded from the CIS	Mandatory
POD_record	These are managed by and down loaded from the CIS	Optional
Location_record	These are managed by and down loaded from the CIS	Optional
Customer_record	These are managed by and down loaded from the CIS	Optional
NOTE The detailed specification for each record type is not given here for the sake of keeping this example specification brief.		

An example of a transaction record is given in Table A.9 below.

Table A.9 – Example of a transaction record

Data element	Context
Transaction_No	Sequential identifier for this transaction, unique within the system
Transaction_Type	One of the predefined types
Amount	The monetary amount for this transaction
Units	The kWh units transferred to the token for this transaction
Time_Stamp	Date and time of this transaction
Receipt_No	Receipt number associated with this transaction, unique within the system
Payment_ID	The payment record that is associated with this transaction
Contract_No	Reference to the supply contract associated with this transaction
Supplier_ID	The supplier associated with this transaction
POD_No	The point of delivery associated with this transaction
Meter_No	The meter for which this token sale was made
Token_ID	The Token_Identifier associated with this transaction

Table A.9 *(continued)*

Data element	Context
Token	The 20 digit number encoded on the token carrier
Tariff_ID	The tariff reference that was applied in this transaction
Tax_ID	Reference to the tax profile if this is a tax collected
Charge_ID	Reference to the auxiliary charge profile if this transaction is a charge collected
Station_ID	The station where this transaction was performed
Shift_Batch_ID	The shift batch associated with this transaction
User_ID	The user that performed this transaction
Auxiliary_Ref_No	A reference to an external system document for which payment is receipted and recorded in this transaction (fines, licence, etc.)
Comment	Reason for this transaction, additional to the predefined types

The exact dimensional attributes of each field shall be the subject of the supply contract and be appropriate to the requirements of the application.

A.6 POS_to_Token_Carrier_Interface

Data formats and prefixes:

D = Decimal

B = Binary

h = Hexadecimal

Numbers without format indicators imply Decimal format.

A.6.1 Application Layer tokens of Class 0, 1, 2 and 3

The application layer token comprises 2 class bits plus 64 data bits to make a 66-bit number. The most significant bits comprise the 2 class bits as depicted in the tables below.

For the actions of these tokens see A.8.4 application layer processes in the Token_Carrier_to_Meter_Interface.

A.6.1.1 Class 0: transfer_Credit

Class	Sub_Class	RND	TID	Amount	CRC
2B	4B	4B	24B	16B	16B
0	0= electricity 1= water 2= gas 3= time 4= currency 5-15= undefined				

A.6.1.2 Class 1: initiate_Meter_Test/Display

Class	Sub_Class	Control	MfrCode	CRC
2B	4B	36B	8B	16B
1	0= STS defined 1-10= reserved 11-15 = proprietary use	Bit position control of test/display number (see STS defined test/display table below) If not used, then set to zero	0	
1	11-15= proprietary use	0= if not used	0-99	

STS defined test / display functions are shown in Table A.10 below.

Table A.10 – Definition of control field

LS Bit No. set	Test No.	Action	Condition
all	0	Do test No.1 to 5 plus optionally any other	Mandatory
1	1	Test the load switch	Mandatory
2	2	Test the meter display device	Mandatory
3	3	Display cumulative kWh register totals	Mandatory
4	4	Display the key revision number	Mandatory
5	5	Display the tariff index	Mandatory
6	6	Test the token reader device	Optional
7	7	Display maximum power limit	Optional
8	8	Display tamper status	Optional
9	9	Display power consumption	Optional
10	10	Display meter version	Optional
11	11	Display phase power unbalance limit	Optional
12	12	Display water factor (water meter only)	Mandatory
13	13	Display tariff rate (currency meter only)	Mandatory

A.6.1.3 Class 2: set_Maximum_Power_Limit

Class	Sub_Class	RND	TID	MPL	CRC
2B	4B	4B	24B	16B	16B
2	0				

A.6.1.4 Class 2: clear_Credit

Class	Sub_Class	RND	TID	Register	CRC
2B	4B	4B	24B	16B	16B
2	1			0= electricity 1= water 2= gas 3= time 4= currency 5 – FFFEh = reserved FFFFh = all registers	

A.6.1.5 Class 2: set_Tariff_Rate

Class	Sub_Class	RND	TID	Rate	CRC
2B	4B	4B	24B	16B	16B
2	2				

A.6.1.6 Class 2: set_1st_Section_ED_Key

Class	Sub_Class	KexpNoHO	KRN	RO	Res	KT	NKHO	CRC
2B	4B	4B	4B	1B	1B	2B	32B	16B
2	3		0-9	0-1	x	0-3		

A.6.1.7 Class 2: set_2nd_Section_ED_Key

Class	Sub_Class	KexpNoLO	TI	NKLO	CRC
2B	4B	4B	8B	32B	16B
2	4		0-99		

A.6.1.8 Class 2: clear_Tamper_Condition

Class	Sub_Class	RND	TID	Pad	CRC
2B	4B	4B	24B	16B	16B
2	5			0	

A.6.1.9 Class 2: set_Maximum_Phase_Power_Unbalance_Limit

Class	Sub_Class	RND	TID	MPPUL	CRC
2B	4B	4B	24B	16B	16B
2	6				

A.6.1.10 Class 2: set_Water_Meter_Factor

Class	Sub_Class	RND	TID	WMfactor	CRC
2B	4B	4B	24B	16B	16B
2	7			0	

A.6.1.11 Class 2: Reserved for future STS use

Class	Sub_Class	RND	TID	ResData	CRC
2B	4B	4B	24B	16B	16B
2	8-10			0	

A.6.1.12 Class 2: Reserved for Proprietary use

Class	Sub_Class	RND	TID	PropData	CRC
2B	4B	4B	24B	16B	16B
2	11-15			0	

A.6.1.13 Class 3: Reserved for future STS use

Class	Sub_Class	Res
2B	4B	60B
3	0-15	

A.6.1.14 Data elements for Application Layer tokens of Class 0, 1, 2 and 3

Table A.11 – Data elements used in tokens

Data element	Name	SPECIFICATION reference
Amount	Transfer _Amount	4.2.4 of NRS009-6-7*
Class	Token_Class	4.2.1 of NRS009-6-7*
Control	Test/display control field	4.2.8 of NRS009-6-7*
CRC	Cyclic_Redundancy_Code	4.2.6 of NRS009-6-7*
KexpNoHO	Key_Expiry_Number_High_Order	4.4.2 of NRS009-7*
KexpNoLO	Key_Expiry_Number_Low_Order	4.4.2 of NRS009-7*
KRN	Key_Revision_Number	4.2.19 of NRS009-6-7*
KT	Key_Type	4.2.20.1 of NRS 009-6-7*
MfrCode	Manufacturer_Code	4.2.7 of NRS009-6-7*
MPL	Maximum_Power_Limit	4.2.10 of NRS009-6-7*
MPPUL	Maximum_Phase_Power_Unbalance Limit	4.2.13 of NRS009-6-7*
NKHO	New_Key_High_Order	4.2.14 of NRS009-6-7*
NKLO	New_Key_Low_Order	4.2.15 of NRS009-6-7*
Pad	Pad value with zeros	zeros
PropData	Proprietary data field	undefined
Rate	Tariff_Rate	undefined
Register	Register selected to clear	4.2.11 of NRS009-6-73*
Res	Reserved	undefined
ResData	Reserved data field for future	undefined
RND	Random_Number	4.2.5 of NRS009-6-7*
RO	Rollover_Key_Change	4.2.20.2 of NRS009-6-7*
Sub_Class	Token_Sub_Class	4.2.2 of NRS009-6-7*
TI	Tariff_Index	4.2.21 of NRS009-6-7*
TID	Token_Identifier	4.2.3 of NRS009-6-7*
WMfactor	Water_Meter_Factor	4.2.16 of NRS009-6-7*
* The NRS documents are listed in Clause 2, Normative references - they constitute IEC/PAS 62055-41.		

A.6.2 Application Layer security functions

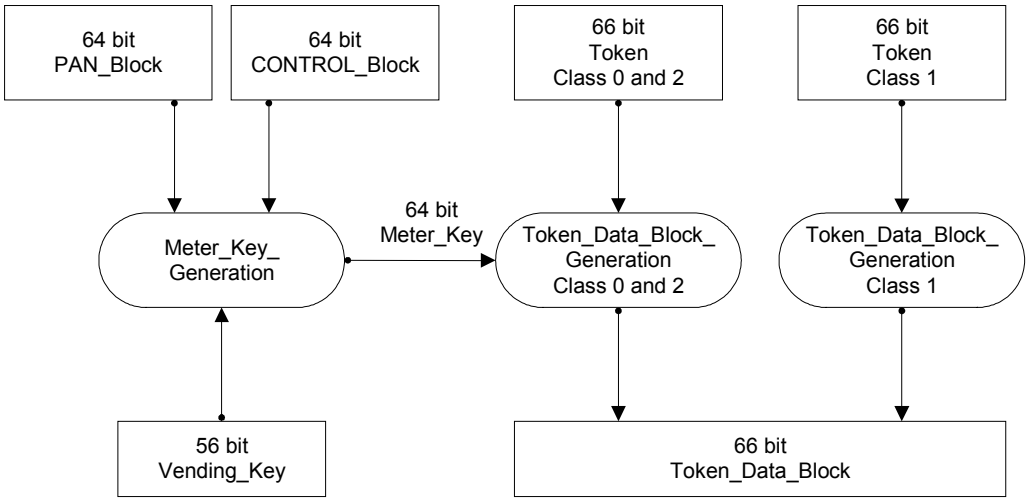


Figure A.1 – Meter_Key and Token_Data_Block generation process

A.6.2.1 Meter_Key_Generation function

Table A.12 – Definition of the Meter_Key_Generation function

Attribute	**Context**
Name	**Meter_Key_Generation** used for encrypting tokens
Class	:= 17; belongs to the generic class = Security
Data Elements	
PAN_Block	64 bit key diversification parameters
CONTROL_Block	64 bit key authentication parameters
Vending_Key	56 bit DES cipher vending key (one of 3 types)
Meter_Key	64 bit STS cipher meter key (one of 3 types)
Methods	
set_PAN_Block()	Set the parameter values
set_CONTROL_Block()	Set the parameter values
set_Vending_Key()	Set the vending key value
get_Meter_Key	Return the meter key value
Operation	
Meter_Key generation	Generates Meter_Key by encrypting PAN_Block and CONTROL_Block using Vending_Key; Returns result in Meter_Key
Association	
None	

NOTE In practice, Meter_Key is generated on the fly and remains inside the secure module, where it is used by other functions and is then discarded.

All operational cryptographic keys shall be generated, stored and used in a secret and physically secure environment and never appear in the open as plain text. A tamper-proof secure module is normally used for the storage and generation of vending keys at the POS, in conjunction with a trusted key management centre.

All vending keys shall be generated and distributed by a trusted and secure key management centre in compliance with its code of practice.

The management and handling of cryptographic keys shall comply with the requirements of NRS009-7.

For terms and definitions see Clause 3 of NRS009-7.

For meter Key_Types see 4.1 of NRS009-7.

For vending Key_Types see 4.2 of NRS009-7.

NOTE The STS provides for key expiry, but to date it has not been implemented in any system.

A.6.2.1.1 Meter_Key generation process

The process for the generation of meter keys is defined in 4.3 of NRS009-7.

A.6.2.1.2 Data Elements for Meter_Key_Generation function

For detailed definitions of PAN_Block and CONTROL_Block see 4.3 of NRS009-7.

The 64-bit PAN_Block comprises of the following data elements:

Table A.13 – Data elements in the PAN_Block

Element	Name	Value	Context
ISOBIN	ISOBIN	6D	Primary_Account_Number issued by ISO
MN	Meter_Number	11D	Annex A of NRS009-6-7

The 64-bit CONTROL_Block comprises of the following data elements:

Table A .14 – Data elements in the CONTROL_Block

Element	Name	Value	Context
SGC	Supply_Group_Code	6D	4.3.6 of NRS009-6-6
KRN	Key_Revision_Number	1D	3.1.23 of NRS009-7
KT	Key_Type	1D	3.1.24 of NRS009-7
TI	Tariff_Index	2D	4.2.21 of NRS009-6-7

The 56-bit Vending_Key is one of the following types:

Table A.15 – Vending Key_Types

Element	Name	Value	Context
VDDK	Vending Default DES Key	56B	Seed key for generating DDTK
VUDK	Vending Unique DES Key	56B	Seed key for generating DUTK
VCDK	Vending Common DES Key	56B	Seed key for generating DCTK

The 64-bit Meter_Key is one of the following types:

Table A.16 – Meter Key_Types

Element	Name	Value	Context
DDTK	Dispenser Default STS Key	64B	Meter_Key for encrypting tokens to the meter and to install in the meter
DUTK	Dispenser Unique STS Key	64B	Meter_Key for encrypting tokens to the meter and to install in the meter
DCTK	Dispenser Common STS Key	64B	Meter_Key for encrypting tokens to the meter and to install in the meter

A.6.2.2 set_ED_Key_Token_Data_Block_Generation function

Table A.17 – Definition of the set_ED_Key_Token_Data_Block_Generation function

Attribute	Context
Name	**set_ED_Key_Token_Data_Block_Generation** used for changing the Meter_Key from a current value to a new value.
Class	:= 17; belongs to the generic class = Security
Data Elements	
1st_Token	66 bit application layer set_1st_Section_ED_Key token
2nd_Token	66 bit application layer set_2nd_Section_ED_Key token
PAN_Block	64 bit current parameters
Current_CONTROL_Block	64 bit current parameters
New_CONTROL_Block	64 bit new parameters
Current_Vending_Key	56 bit DES cipher vending key (one of 3 types)
New_Vending_Key	56 bit DES cipher vending key (one of 3 types)
Current_Meter_Key	64 bit STS cipher meter key (one of 3 types)
New_Meter_Key	64 bit STS cipher meter key (one of 3 types)
1st_Token_Data_Block	66 bit set_1st_Section_ED_Key token data block
2nd_Token_Data_Block	66 bit set_2nd_Section_ED_Key token data block
Methods	
set_1st_Token()	Set the APDU value for 1st section of meter key
set_2nd_Token()	Set the APDU value for 2nd section of meter key
set_PAN_Block()	Set the parameter values for the meter in question
set_Current_CONTROL_Block()	Set current parameters
set_New_CONTROL_Block()	Set new parameters
set_Current_Vending_Key()	Set the current vending key value associated with the meter
set_New_Vending_Key()	Set the new vending key value associated with the meter
set_Current_Meter_Key()	Set the current meter key value
set_New_Meter_Key()	Set the new meter key value
get_1st_Token_Data_Block()	Return the data for encoding onto 1st token carrier of key change pair
get_2nd_Token_Data_Block()	Return the data for encoding onto 2nd token carrier of key change pair

Table A.17 *(continued)*

Operation	
Token_Data_Block generation	a) Obtains Current_Meter_Key from Generate_Meter_Key function by using PAN_Block, Current_CONTROL_Block and Current_Vending_Key; b) Obtains New_Meter_Key from Generate_Meter_Key function by using PAN_Block, New_CONTROL_Block and New_Vending_Key; c) Inserts the 32 HO bits of New_Meter_Key into the NKHO field of 1st_Token; d) Inserts the 32 LO bits of New_Meter_Key into the NKLO field of 2nd_Token; e) Encrypts the 64 LO bits of modified 1st_Token using Current_Meter_Key and re-positions the 2 class bits; f) Encrypts the 64 LO bits of modified 2nd_Token using Current_Meter_Key and re-positions the 2 class bits; g) Returns 1st_Token_Data_Block for encoding onto a token carrier; h) Returns 2nd_Token_Data_Block for encoding onto a token carrier
Association	
Generate_Meter_Key function	Calls on Generate_Meter_Key function to generate Current_Meter_Key and New_Meter_Key

NOTE 1 Any combination of Current or New_CONTROL_Block and Vending_Key is possible, but PAN_Block can only have current parameters (present implementations only).

NOTE 2 The NKHO and NKLO fields of the input arguments 1st_Token and 2nd_Token are in a “don’t care” state.

A.6.2.2.1 Set_ED_Key_Token_Data_Block generation process

The meter key shall change whenever one or more of the following conditions exist:

- the associated Vending_Key changes;
- the Key_Type changes;
- the Key_Revision_Number changes;
- the Supply_Group_Code changes;
- the Tariff_Index changes;
- the Key_Expiry_Number changes.

Meter_Key changes shall comply with 4.4 of NRS009-7.

Encryption of the 64 LO bits of modified 1st_Token using Current_Meter_Key is in accordance with 4.6 of NRS009-6-7 and the re-positioning of the 2 class bits is in accordance with 4.1 of NRS009-6-9 to yield the 66 bit Token_Data_Block, ready for encoding onto a token carrier.

Encryption of the 64 LO bits of modified 2nd_Token using Current_Meter_Key is in accordance with 4.6 of NRS009-6-7 and the re-positioning of the 2 class bits is in accordance with 4.1 of NRS009-6-9 to yield the 66 bit Token_Data_Block, ready for encoding onto a token carrier.

A.6.2.2.2 Data Elements for Set_ED_Key_Token_Data_Block_Generation function

Data elements associated with the Vending_Key are shown in Table A.18 below.

Table A.18 – Data elements associated with the Vending_Key

Element	Name	Association means	SPECIFICATION
KRN	Key_Revision_Number	database	3.1.23 of NRS009-7
KT	Key_Type	database	3.1.24 of NRS009-7
SGC	Supply_Group_Code	database	4.3.6 of NRS009-6-6
KexpNo	Key_Expiry_Number	database	4.4.2 of NRS009-7
KactDate	Key_Activation_Date	database	4.4.4 of NRS009-7

NOTE If any of the above data elements change their value, then the Vending_Key shall change as well, with a corresponding meter key change.

Data elements associated with the Meter_Key are shown in Table A.19 below.

Table A.19 – Data elements associated with the Meter_Key

Element	Name	Association means	SPECIFICATION
KRN	Key_Revision_Number	CONTROL_Block	3.1.23 of NRS009-7
KT	Key_Type	CONTROL_Block	3.1.24 of NRS009-7
SGC	Supply_Group_Code	CONTROL_Block	4.3.6 of NRS009-6-6
TI	Tariff_Index	CONTROL_Block	4.2.21 of NRS009-6-7
KexpNo	Key_Expiry_Number	Key change token	3.1.22 of NRS009-7
ISOBIN	ISOBIN	PAN_Block	
MN	Meter_Number	PAN_Block	
Vk	Vending_Key	Key generation	

NOTE If any of the above data elements change their value, then the Meter_Key shall change as well.

For definitions of PAN_Block, CONTROL_Block, vending Key_Type and meter Key_Type, see A.6.2.1.2 Data for Meter_Key_Generation function.

The 1st_Token_Data_Block and the 2nd_Token_Data_Block format is in accordance with 4.1 of NRS009-6-9.

NOTE 1 In present system implementations, it is not possible to change the Meter_Key if the ISOBIN or the meter number changes. This is a practical constraint and not a principle one.

NOTE 2 Key expiry for the Meter_Key is not implemented in any meters at the present time.

A.6.2.3 Class_0_Class_2_Token_Data_Block_Generation function

Table A.20 – Definition of the Class_0_Class_2_Token_Data_Block_Generation function

Attribute	Context
Name	**Class_0_Class_2_Token_Data_Block_Generation** Encryption of class 0 and class 2 tokens in preparation for encoding onto a token carrier.
Class	:= 17; belongs to the generic class = Security
Data Elements	
Token	66 bit application layer class 0 or class 2 token
PAN_Block	64 bit current parameters
CONTROL_Block	64 bit current parameters

Table A.20 *(continued)*

Attribute	**Context**
Vending_Key	56 bit DES cipher vending key (one of 3 types)
Meter_Key	64 bit STS cipher meter key (one of 3 types)
Token_Data_Block	66 bit token data block ready for encoding onto a token carrier
Methods	
set_Token()	Set APDU data
set_PAN_Block()	Set meter associated parameters
set_CONTROL_Block()	Set meter associated parameters
set_Vending_Key()	Set current vending key value
get_Token_Data_Block()	Return the data to be encoded onto the token carrier
Operation	
Token_Data_Block generation	a) Obtains Meter_Key from Generate_Meter_Key function by using PAN_Block, CONTROL_Block and Vending_Key; b) Encrypts the 64 LO bits of Token using Meter_Key and re-positions the 2 class bits. Returns Token_Data_Block for encoding onto a token carrier
Association	
Generate_Meter_Key function	Calls on Generate_Meter_Key function to generate Meter_Key

NOTE This function is not applicable to the set_1st_ED_Key and set_2nd_ED_Key tokens. For the relevant function see A.6.2.2

A.6.2.3.1 Class 0 and Class 2 Token_Data_Block generation process

Encryption of the 64 LO bits of Token using Meter_Key is in accordance with 4.6 of NRS009-6-7 and the re-positioning of the 2 class bits is in accordance with 4.1 of NRS009-6-9 to yield the 66 bit Token_Data_Block, ready for encoding onto a token carrier.

A.6.2.3.2 Data Elements for Class 0 and Class 2 Token_Data_Block_Generation function

For definitions of PAN_Block, CONTROL_Block, vending Key_Type and meter Key_Type see A.6.2.1.2 Data Elements for Meter_Key_Generation function.

The Token_Data_Block format is in accordance with 4.1 of NRS009-6-9.

A.6.2.4 Class_1_Token_Data_Block_Generation function

Table A.21 – Definition of the Class_1_Token_Data_Block_Generationfunction

Attribute	**Context**
Name	**Class_1_Token_Data_Block_Generation** Processing of class 1 token in preparation for encoding onto a token carrier.
Class	:= 16; belongs to the generic class = Data Exchange

Table A.21 (continued)

Data Elements	
Token	66 bit application layer class 1 token
Token_Data_Block	66 bit Token_Data_Block ready for encoding onto token carrier

Methods	
set_Token ()	Set data in APDU
get_Token_Data_Block()	Return data for encoding onto a token carrier
Operation	
Token_Data_Block generation	a) Re-positions the 2 class bits within the 66-bit Token_Data_Block without encrypting the low order 64 bits; b) Returns Token_Data_Block for encoding onto a token carrier.
Association	
None	

NOTE This Token_Class gets treated the same as the class 0 and class 2 tokens, except that it does not get encrypted.

A.6.2.4.1 Class_1_Token_Data_Block_Generation process

The re-positioning of the 2 class bits is in accordance with 4.1 of NRS009-6-9 to yield the 66-bit Token_Data_Block, ready for encoding onto a token carrier.

A.6.2.4.2 Data Elements for Class 1 Token_Data_Block_Generation function

The Token_Data_Block format is in accordance with 4.1 of NRS009-6-9.

A.6.3 Physical Layer functions for Numeric token carrier

This is a one-way connection-less protocol where the numeric code is transported by the customer to the meter and then presented to the meter by a suitable reader device, typically a keypad.

For the decimal format requirements, it shall comply with 4.1.3 of NRS009-6-9.

For the physical token definition requirements, it shall comply with 4.2 of NRS009-6-9.

A.6.4 Physical Layer functions for disposable Magnetic card token carrier

This is a one-way connection-less protocol where the magnetic card is transported by the customer to the meter and then presented to the meter by a suitable magnetic card reader device.

For the physical token definition requirements, it shall comply with 4.1 of NRS009-6-8.

For the dimensions requirements, it shall comply with 4.2 of NRS009-6-8.

For the location of the magnetic stripe requirements, it shall comply with 4.3 of NRS009-6-8.

For the characteristics of the magnetic stripe and encoding technique requirements, it shall comply with 4.4 of NRS009-6-8.

For the information contents, it shall comply with 4.5 of NRS009-6-8.

A.7 Token_Carrier

The token carrier is defined in the physical layer of the POS_to_Token_Carrier_Interface and the Token_Carrier_to_Meter_Interface. It essentially defines the encoding of the 66-bit Token_Data_Block onto various token carriers for transfer to the meter, or the decoding of the 66-bit Token_Data_Block from various token carriers.

A.7.1 Numeric token carrier

For the detailed specification, see A.6.3.

A.7.2 Disposable Magnetic card token carrier

For the detailed specification, see A.6.4.

A.8 Token_Carrier_to_Meter_Interface

This interface may be a function in a single-part payment meter installation or it may be a separate entity in a multi-part payment meter installation.

In this example, the type tests are specified as if for a multi-part payment meter installation.

Where this function is integrated with a single-part payment meter installation, the type tests may be conveniently grouped with those of other functions and be executed together.

A.8.1 Physical Layer functions for numeric token carrier

The token shall be entered by means of a keypad device on the meter.

For the complete definition, see A.6.3.

Pre-payment meters, that operate with numeric token carriers shall:

- display the numbers entered during token entry;
- have the means to remove digits, one at a time, from the end of a partially entered number, for example, a "Backspace" button;
- have the means to clear a partially entered number, for example, a "Clear" or "Enter" button.

Output from this function is a 66-bit Token_Data_Block for further processing in the application layer.

A.8.2 Physical Layer functions for disposable magnetic card token carrier

The token shall be entered by means of a suitable reader device on the meter.

For the magnetic erasure requirements, it shall comply with 4.6 of NRS009-6-8.

For the complete definition, see A.6.4.

Output from this function is a 66-bit Token_Data_Block for further processing in the application layer.

A.8.3 Application Layer security functions

A.8.3.1 Set_ED_Key_Token_Extraction function

Table A.22 – Definition of the Set_ED_Key_Token_Extraction function

Attribute	**Context**
Name	**Set_ED_Key_Token_Extraction** Used for changing the Meter_Key from a current value to a new value.
Class	:= 17; belongs to the generic class = Security
Data Elements	
1st_Token_Data_Block	66 bit set_1st_Section_ED_Key Token_Data_Block as read from a token carrier
2nd_Token_Data_Block	66 bit set_2nd_Section_ED_Key Token_Data_Block as read from a token carrier
Meter_Key	64 bit STS cipher meter key (one of 3 types)
1st_Token	66 bit application layer set_1st_Section_ED_Key token
2nd_Token	66 bit application layer set_2nd_Section_ED_Key token
Methods	
set_1st_Token_Data_Block()	Set the 1st section meter key value in preparation
set_2nd_Token_Data_Block()	Set the 2nd section meter key value in preparation
set_Meter_Key()	Set the current meter key value
get_1st_Token()	Return the decrypted 1st section new meter key value
get_2nd_Token()	Return the decrypted 2nd section new meter key value
Operation	
Key change token extraction	a) Decrypts the 64 LO bits of 1st_Token_Data_Block using Meter_Key and re-positions the 2 class bits; b) Decrypts the 64 LO bits of 2nd_Token_Data_Block using Meter_Key and re-positions the 2 class bits; c) Authenticates 1st_Token by comparing the CRC; d) Authenticates 2nd_Token by comparing the CRC; e) Erases last entered set_ED_Key token on the token carrier if possible; f) Returns 1st_Token for further processing in the application layer; g) Returns 2nd_Token for further processing in the application layer
Association	
None	

NOTE The storage of Meter_Key and associated processing within this function need not take place inside a special secure module. The meter firmware is deemed to be a secure environment if it satisfies the certification requirements as determined by the STS Association.

A.8.3.1.1 Set_ED key token extraction process

Meter_Key changes shall comply with 4.4 of NRS009-7.

The 64 low order bits of the 66 bit 1st_Token_Data_Block are decrypted using Meter_Key in accordance with 4.7 of NRS009-6-7 and the 2 class bits are re-positioned as the inverse process defined in 4.1 of NRS009-6-9 to yield the 66 bit set_1st_Section_ED_Key token for further processing in the application layer.

Authenticates 1st_Token by calculating the CRC and comparing it to the CRC in 1st_Token.

The 64 low order bits of the 66 bit 2nd_Token_Data_Block are decrypted using Meter_Key in accordance with 4.7 of NRS009-6-7 and the 2 class bits are re-positioned as the inverse process defined in 4.1 of NRS009-6-9 to yield the 66 bit set_2nd_Section_ED_Key token for further processing in the application layer.

Authenticates 2nd_Token by calculating the CRC and comparing it to the CRC in 2nd_Token.

Erases last entered Set_ED_Key token on the Token_Carrier if it is possible, but only if the meter application process successfully executed the key change.

A.8.3.1.2 Data Elements for Set_ED key token extraction function

The 1st_Token_Data_Block and the 2nd_Token_Data_Block format are in accordance with 4.1 of NRS009-6-9.

For detailed definitions of the token types and associated data elements, see A.6.1 application layer tokens of class 0, 1, 2 and 3.

NOTE: Key expiry for Meter_Key is not implemented in any meters at the present time.

A.8.3.2 Class_0_and_Class_2_Token_Extraction function

Table A.23 – Definition of the Class 0 and Class 2 token extraction function

Attribute	**Context**
Name	**Class_0_and_Class_2_Token_Extraction** Extracts the token from the Token_Data_Block. All class 0 and class 2 tokens except *Set_ED key Token*
Class	:= 17; belongs to the generic class = Security
Data Elements	
Token_Data_Block	66 bit Token_Data_Block as read from a token carrier
Meter_Key	64 bit STS cipher meter key (one of 3 types)
Token	66 bit application layer token
Methods	
set_Token_Data_Block()	Set the token data read from the token carrier
set_Meter_Key()	Set the current meter key
get_Token()	Return the decrypted token data
Operation	
Class 0 and 2 token extraction	a) Decrypts the 64 LO bits of Token_Data_Block using Meter_Key and re-positions the 2 class bits; b) Authenticates Token by comparing the CRC; c) Validates Token by comparing the TID with previously stored TIDs; d) Returns Token for further processing in the application layer; e) Cancels Token by storing the TID (only if application process. executes Token successfully) f) Erases Token on the token carrier if possible; (only if application process executes Token successfully)
Association	
None	

NOTE This function is not applicable to the set_1st_ED_Key and set_2nd_ED_Key tokens. For the relevant function, see A.8.4.1.

A.8.3.2.1 Class_0_and_Class_2_Token_Extraction process

The 64 low order bits of the 66-bit Token_Data_Block is decrypted using Meter_Key in accordance with 4.7 of NRS009-6-7 and the 2 class bits are re-positioned as the inverse process defined in 4.1 of NRS009-6-9.

Authenticates Token by calculating the CRC and comparing it to the CRC in Token.

Validates Token by comparing the TID with previously stored TIDs.

Returns the 66-bit token for further processing in the application layer.

Cancels Token by storing the TID for later comparison, but only if the meter application process successfully executed the instruction transferred in Token.

If the Token_Carrier allows it, then the Token on the Token_Carrier is physically erased from the Token_Carrier, but subject to the same conditions as for cancellation. For example: magnetic card or solid state memory.

A.8.3.2.2 Data Elements for Class_0_and_Class_2_Token_Extraction function

The Token_Data_Block format is in accordance with 4.1 of NRS009-6-9.

For detailed definitions of the token types and associated data elements, see A.6.1 application layer tokens of class 0, 1, 2 and 3.

A.8.3.3 Class_1_Token_Extraction function

Table A.24 – Definition of the Class_1_Token_Extraction function

Attribute	**Context**
Name	**Class_1_Token_Extraction** Extracts the token from the Token_Data_Block for class 1 tokens only
Class	:= 16; belongs to the generic class = Data Exchange
Data Elements	
Token_Data_Block	66 bit Token_Data_Block as read from a token carrier
Token	66 bit application layer token
Methods	
set_Token_Data_Block()	Set the token data read from the token carrier
get_Token()	Return the re-formatted token data
Operation	
Class 1 token extraction	a) Re-positions the 2 class bits within the 66 bit Token_Data_Block without decrypting the low order 64 bits; b) Validates Token by comparing the CRC and MfrCode; c) Returns Token for further processing in the application layer
Association	
None	

NOTE This token class gets treated the same as the class 0 and class 2 tokens, except that it does not get decrypted, nor does it have a token identifier for prevention of replay, nor does it get erased if the Token_Carrier is a magnetic card.

A.8.3.3.1 Class_1_Token_Extraction process

The 2 class bits are extracted and together with the remaining 64 bits re-positioned as the inverse of the process defined in 4.1 of NRS009-6-9.

Validates Token by calculating the CRC and comparing it to the CRC in Token and by comparing the MfrCode stored in the meter with that in Token.

Returns the 66-bit token for further processing in the application layer.

A.8.3.3.2 Data Elements for Class_1_Token_Extraction function

The Token_Data_Block format is in accordance with 4.1 of NRS009-6-9.

For detailed definitions of the token types and associated data elements, see A.6.1.

A.8.3.4 Token_Authentication process

Authentication of a presented token shall be by validation of the CRC checksum. This is implicit in the fact that a successful decryption and a valid CRC indicate that the same key was used in the POS.

A.8.3.5 Token_Validation process

Validation of a presented token of class 0 and class 2 tokens shall be by means of the Token_Identifier and by means of the Manufacturer_Code for class 1 tokens.

Any token identifier received that is already stored shall result in the rejection of the token that contains this identifier.

If a token identifier is received that has a value less than the smallest token identifier stored (in other words, that was issued by a CDU before the earliest token stored in the ED), the ED shall reject the token containing this identifier.

A.8.3.6 Token_Cancellation process

Cancellation of a token shall be by means of storing the Token_Identifier in addition to erasure of magnetic tokens.

The time-based Token_Identifier is used to uniquely identify each ED-specific token. The ED shall store, in the non-volatile memory, at least the last 50 token identifiers received.

If a token identifier is received that has a value greater than the smallest token identifier stored (in other words, that is a valid token) and there is no available space in the non-volatile memory to store the received token identifier, the ED shall accept this token, remove the smallest token identifier (in other words, the oldest token) from the non-volatile memory, and replace it with the new token identifier.

If the ED accepts a key change, the used token identifier store shall remain unchanged, unless the rollover control flag specifies that the store be cleared.

It shall not be possible for the identifier table in the meter's non-volatile memory to contain entries that indicate a date and time before the existence of the meter, or a date and time earlier than the repair date of a repaired meter, when it leaves the factory.

This means that the tables in new and repaired meters shall be filled with identifiers that indicate a recent date and time. For example: the date and time of manufacture or repair.

It shall be possible to read and process the token (as well as erase it when required) on a single insertion without further action from the user.

The following tokens shall not be erased:

- an expired (or old) "Credit token";
- "Non-Dispenser specific management tokens";
- the "Key change token" which is inserted first.

The "Key change token" which is inserted last, shall be erased upon successful completion of the key change operation.

The pre-payment meter shall never accept any credit tokens that are encrypted under a default key.

A pre-payment meter in the default state (i.e. with a default key in use) shall accept all the relevant "Non-Dispenser specific management tokens" as well as "Key change tokens" encoded under the default key.

The pre-payment meter shall still accept tokens when in the power limiting or tampered state.

A.8.4 Application Layer token processes

For the detailed definitions of the tokens for classes 0,1,2 and 3, see A.6.1.

A.8.4.1 Class 0: transfer_Credit token

The credit amount in the token shall be added to the available credit in the accounting function.

A.8.4.2 Class 1: initiate_Meter_Test/Display token

The relevant test shall be executed or the relevant information shall be displayed.

When more than one output is required, for example for test number 0, the outputs shall be initiated in the order in which they are defined in A.6.1.2. An optional test may be omitted if it is not implemented. A single test, for example test number 3, may provide more than one field of information.

In the case where the Sub_Class value is in the range 11 to 15, the relevant test or display function shall be executed according to the manufacturer's specification, but the pre-payment meter shall verify the MfrCode before such a token is accepted.

The pre-payment meter may optionally be set into a test mode and allow the user to select individual tests manually.

A.8.4.3 Class 2: set_Maximum_Power_Limit token

The current value of the maximum power limit allowed by the customer's load circuit shall be replaced with the new value and the new value shall become the current value.

A.8.4.4 Class 2: clear_Credit token

The available credit in the accounting function shall be set to zero.

A.8.4.5 Class 2: set_Tariff_Rate token

The current tariff rate shall be replaced with the new tariff rate and the new tariff rate shall become the current tariff rate.

A.8.4.6 Class 2: set_1st_Section_ED_Key token

The current meter key shall be replaced with the new meter key and the new meter key shall become the current meter key.

This action is subject to the successful receipt of both the set_1st_Section_ED_Key and set_2nd_Section_ED_Key tokens.

The pre-payment meter shall have only one active key at any stage of its operation. Dual keys shall not be used.

It shall be possible to enter the two key change tokens in any order to affect a successful key change.

It shall be possible to enter at least two other invalid tokens in any order along with key change tokens and still perform a successful key change.

It shall be possible to enter the same key change token more than once, if the key has not been changed already, and still perform a successful key change.

A time-out function shall be used to cancel a partially completed key change procedure after a duration of between 30 s and 10 min.

A.8.4.7 Class 2: set_2nd_Section_ED_Key token

See A.8.4.6 above.

A.8.4.8 Class 2: clear_Tamper_Condition token

The status indicator that indicates a tamper condition shall be reset to indicate a non-tamper condition.

A.8.4.9 Class 2: set_Maximum_Phase_Power_Unbalance_Limit token

The maximum phase power unbalance limit shall be set to the new value and the new value shall become the current value.

A.8.4.10 Class 2: set_Water_Meter_Factor token

Where a meter supports pre-payment water functions, the current factor shall be replaced by the new factor and the new factor shall become the current factor.

A.8.4.11 Class 2: Reserved for future STS use token

These token types shall be rejected.

A.8.4.12 Class 2: Reserved for Proprietary use token

The actions performed in the meter shall be in accordance with the manufacturer's specifications.

A.8.4.13 Class 3: Reserved for future STS use token

These token types shall be rejected.

A.8.5 Display functions

In addition to the display functions given in A.8.4.2, the following conditions shall be uniquely indicated:

- the acceptance of a token;
- the rejection of a token;
- when a token is old (or expired);
- when a token has already been used, i.e. duplicate token;
- after a successful completion of a key change operation.

In all cases where the pre-payment meter provides configuration information, the “key type” shall be considered part of the “key revision number” information. The meter shall therefore always provide the “key type” information together with, or else directly after, the “key revision” information.

A.8.6 General security functions

Provision for the sealing of the terminals shall be provided in accordance with the particular requirements of the purchase contract.

Provision for the sealing of the Token_Carrier_to_Meter_Interface components shall be provided in accordance with the particular requirements of the purchase contract.

In the case of a multi-part installation the connection means and the communications protocol between the parts, and the storage of the meter key shall not be less secure than as if it were a single-part installation.

Protection shall be provided against malfunction due to the ingress of vermin, by conformal coating of any printed circuit boards that may be used.

No combination of influence quantities within the limits specified in this specification shall cause the meter to supply unmetered electricity, fail to interrupt the load on expiry of credit or execute unspecified load interruptions.

A.8.7 Type test requirements

The requirements given in Clause 10 of IEC 62055-31 shall apply.

When subjected to environmental stress tests, a sample of pre-payment meters shall demonstrate satisfactory operation equivalent to at least 10 years of continuous field operation.

A.9 Payment meter

See Figure 6 for a functional block diagram of a single-part payment meter installation.

The payment meter shall have the following functional attributes:

- **Token_Carrier_to_Meter_Interface**:
  - Type STS numeric or magnetic card token carrier;
  - STS credit token types and STS management token types.
- **Metering function**:
  - For active energy Class 2;
  - Supply interface terminals to connect to the supply network.
- **Delivery function**:
  - Plug-in unit with matching socket;
  - Load interface terminals to connect to the customer's load circuit;
  - Load Switch with automatic or manual restoration.
- **Accounting function**:
  - Operate in pre-payment mode;
  - Accounting mode in kWh units;
  - With token credit function;
  - Without emergency credit function;
  - Without auxiliary charges function, without tariff function.
- **Display functions**: as detailed in the function specifications below.
- **Security functions**: as detailed in the function specifications below.
- **Recording functions**: as detailed in the function specifications below.
- **Test functions**: as detailed in the function specifications below.

The response of the payment meter to energy flowing in the reverse direction shall be agreed between the manufacturer and the purchaser. However, any reverse energy measured by the meter shall be recorded in a separate cumulative register to the main register(s) used for recording of energy consumption; the latter shall only record the forward energy.

The payment meter may consist of a single-part installation or a multi-part installation, the option of which shall be the subject of the supply contract between the meter manufacturer and the supplier.

This example specification addresses mainly the particular requirements for a single-part installation, but references are also made in relevant clauses where consideration needs to be given to a multi-part installation.

For the purposes of testing, in the case of a multi-part installation, all the parts shall be connected together as if for an actual installation in accordance with the manufacturer's specification and the relevant tests shall be conducted on the combined set.

In this example specification, the type tests are specified for each function as if each function were to be embodied in a different part of a multi-part payment meter installation.

Where more than one function is embodied in a single part, the complete part shall be subjected to the test conditions when a test for the particular function is performed.

Where specific tests are common to more than one function, then such tests may be conveniently grouped and be executed simultaneously.

In the case of a multi-part installation the level of security of each part shall be not less than as if the various functions of each part were all contained in a single part and the level of security of the connections between the parts shall be not less than as if the various functions of each part were embodied in a single part.

A.9.1 Metering function

Table A.25 – Definition of the Metering function

Attribute	**Context**
Name	**Metering function**
Class	:= 7; belongs to the generic class = Metering
Data Elements	
Cumulative_Total_Register	Cumulative record of delivered energy
Incremental_Register	Incremental record of delivered energy (dynamic); typically electrical pulses
Consumption_Rate	Typically optical pulses per kWh
Meter_Details	Details relevant to manufacturing process
Voltage_Registers	Optional voltage measurements
Power_Registers	Optional power measurements
Power_Factor_Registers	Optional power factor measurements
Phase_Unbalance_Registers	Optional phase unbalance measurements
Meter_Serial_Number	Associated serial number of metering device
Methods	
set_Meter_Details()	Set parameters with the values from token carrier
get_Cumulative_Total_Register()	Return the value onto the token carrier
get_Incremental_Register()	Return the value onto the token carrier
get_Meter_Details()	Return the values onto the token carrier
get_Voltage_Registers()	Return the values onto the token carrier
get_Power_Registers()	Return the values onto the token carrier
get_Power_Factor_Registers()	Return the values onto the token carrier
get_Phase_Unbalance_Registers()	Return the values onto the token carrier
get_Meter_Serial_Number()	Return the value onto the token carrier
clear_Cumulative_Total_Register	Clear the value to zero
clear_Incremental_Register	Clear the value to zero
display_Cumulative_Total_ Register	Display the value on the payment meter display device
display_Incremental_Register	Display the value on the payment meter display device
display_Consumption_Rate	Display the value on the payment meter display device
display_Meter_Details	Display the values on the payment meter display device
display_Voltage_Registers	Display the values on the payment meter display device
display_Power_Registers	Display the values on the payment meter display device
display_Power_Factor_Registers	Display the value son the payment meter display device
display_Phase_Unbalance_ Registers	Display the values on the payment meter display device
display_Meter_Serial_Number	Display the value on the payment meter display device

Table A.25 *(continued)*

Attribute	Context
Operation	
Supply interfacing	Provides a means for connecting to the supply network
Energy measurement	Measures the delivered active energy (total in the case of poly=phase)
Voltage measurement	Optionally measures Voltage
Power measurement	Optionally measures Power
Power factor measurement	Optionally measures Power Factor
Phase unbalance measurement	Optionally measures Phase Unbalance
Measurement registration	Records the measurements
Metered supply provision	Provides a metered supply to the delivery equipment connected to the customer's load circuit
Association	
Display function	a) Indicator for the consumption rate; b) Display of the cumulative consumption register contents; c) Display values of data elements; d) Markings on the name plate and terminal covers
Security function	a) Sealing of terminals; b) Sealing of metrological components; c) Protection of the connection and protocol between parts; d) Protection of the cumulative register contents; e) Protection of access to the cable entry points; f) Protection against malfunction; g) Failure mode under a combination of influence quantities; h) Data integrity.
Recording function	a) Cumulative recording of measured electrical energy supplied to the delivery equipment; b) Recording of the data elements; c) Meter serial number
Test function	Activation of a calibrated consumption rate indicator for interfacing to calibration equipment

A.9.1.1 Metering processes

The electrical energy being supplied to the delivery equipment shall be continuously measured and such measurements shall be made available to other functions in real time.

Measurements shall be of accuracy Class 2 for active energy unless otherwise specified by the particular supply contract between the meter manufacturer and the supplier.

The measurements shall be cumulatively recorded during the active lifetime of the meter and shall optionally be capable of being cleared by means of a special token.

The smallest quantum of measurements shall be recorded in an incremental register for the use of other functions and the resolution shall be not less than that of the operational resolution of the accounting function.

A secure supply interface (set of terminals) for the connection to the incoming supply shall be provided according to the particular requirements of the purchase contract.

A secure metered supply interface to the delivery equipment shall be provided, if the delivery equipment is not integral with the metering equipment (i.e. multi-part installation).

NOTE 1 For constructional requirements, sealing and terminal arrangements the requirements given in the relevant national standards would apply.

NOTE 2 This is an example of a standard specific to the South African industry for a single-part pre-payment meter, consisting of a plug-in unit and a matching socket arrangement.

Optionally it may measure voltage, power, power factor and phase unbalance for use of other functions.

A.9.1.2 Display functions

A consumption rate indicator shall be provided for the use of the consumer. The consumption rate indicator light shall emit visible red light with radiation strength of at least 200 μW/cm² when measured at a distance of 10 mm from the surface of the meter. The radiation strength is measured over a reference surface of 0,5 cm². This indicator may double up as the optical test output device required in A.9.1.5.

A means for displaying the contents of the recorded Cumulative_Total_Register shall be provided. (See also recording function below.)

A means for displaying optional measurements of voltage, power, power factor and phase unbalance shall be provided.

For the markings on the nameplate and terminal covers, the requirements given in 5.12 of IEC 62055-31 shall apply.

A.9.1.3 Security functions

Provision for the sealing of all terminals shall be provided in accordance with the particular requirements of the purchase contract.

Provision for the sealing of the metrological components shall be provided in accordance with the particular requirements of the purchase contract.

In the case of a multi-part installation, the interface, connection means, the communications protocol between the parts, and the contents of all the registers shall be not less secure than as if it were a single-part installation.

The supply cable entry and load cable exit shall be such as to minimize opportunities for vandalism and the electrical bypassing of the meter.

Protection shall be provided against malfunction due to the ingress of vermin, by conformal coating of any printed circuit boards that may be used.

No combination of influence quantities within the limits specified in this specification shall cause the meter to supply unmetered electricity, fail to interrupt the load on expiry of credit or execute unspecified load interruptions.

Appropriate techniques such as CRC checksums shall be employed to ensure a high level of data integrity of all registers.

A.9.1.4 Recording functions

The metered cumulative active energy supplied to the delivery equipment during the lifetime of the meter shall be continuously recorded. (See also A.9.1.7 for more detailed requirements of the data elements).

The information can be recorded either by an electromechanical register or an electronic non-volatile memory register.

The non-volatile memory shall have a minimum retention time of four months in the event of power supply loss to the unit.

NOTE Longer retention time of the non-volatile memory shall be the subject of purchase contract.

The register shall be able to record, starting from zero, for a minimum of 1 500 h, the energy corresponding to maximum current at reference voltage and unity power factor.

NOTE Higher values than 1 500 h shall be the subject of the purchase contract.

It shall be impossible to reset the Cumulative_Total_Register during normal use, but it may optionally be capable of being cleared by means of a special token under strict management control policy.

NOTE The regular roll over of the display is not considered as a reset.

The resolution of the Cumulative_Total_Register shall be not less than that of the operational resolution of the accounting function.

A meter serial number shall be allocated and permanently recorded on the front panel of the meter.

The meter serial number may optionally be recorded in the non-volatile memory together with other related information such as date of manufacture and name of manufacturer.

A.9.1.5 Test functions

An optical test output shall be provided for the purposes of verifying the calibration of the metrological properties of the meter. The output device shall comply with the requirements of 5.11 of IEC 62055-31.

A.9.1.6 Data_Exchange function

A secure interface for the exchange of measurement information with other functions shall be provided if such other functions are not integral with the metering equipment.

A.9.1.7 Data elements

Table A.26 – Definition of the Cumulative_Total_Register

Attribute	**Context**
Name	**Cumulative_Total_Register**
Structure	Units: kWh Integer part: 5 digits minimum Decimal part: 2 digits minimum
Context	Record of cumulative total active energy delivered
Associations	None
Access mode	Read and write
Triggers	Not applicable

A.9.1.8 Type test requirements

The requirements given in clause 10 of IEC 62055-31 shall apply.

When subjected to environmental stress tests, a sample of pre-payment meters shall demonstrate satisfactory operation equivalent to at least 10 years of continuous field operation.

A.9.2 Delivery function

Table A.27 – Definition of the Delivery function

Attribute	**Context**
Name	**Delivery function**
Class	:= 8; belongs to the generic class = Delivery
Data Elements	
Configuration_Profile	Profile of parameters that set the configuration of the delivery equipment
:Voltage_Lower_Limit	Undervoltage monitoring set point
:Voltage_Upper_Limit	Overvoltage monitoring set point
:Power_Limit	Power monitoring set point
:Interrupt_Control	Rule-set for interruption of supply to load circuit
:Restore_Control	Rule-set for restoration of supply to load circuit (automatic/manual)
:Equipment_Serial_Number	Identification information
:Manufacturing_Details	Manufacturing information
Status_Profile	Profile of parameters indicating the status of the delivery equipment performance
:Load_Switch_State	Mechanical position of the contacts (open/closed)
:Last_Interrupt_Cause	Cause for the last opening of the load switch
:Number_of_Interrupts	Count of the number of times the load switch has operated
:Incoming_Supply_Status	Whether voltage is present on the input terminals of the equipment
:Delivery_Supply_Status	Whether voltage is present on the output terminals of the equipment
:Tamper_Detection_Status	Optional detection of unauthorized access
Methods	
set_Configuration_Profile()	Set parameters with the values from the token carrier
get_Configuration_Profile()	Return the values onto the token carrier
display_Configuration_Profile	Display the values on the payment meter display device
clear_Status_Profile	Clear the values to zero
get_Status_Profile()	Return the values onto the token carrier
display_Status_Profile	Display the values on the payment meter display device
Operation	
Supply interfacing	Provides a set of input supply terminals for connection to the metered supply if the metering equipment is physically separate from the delivery equipment
Load interfacing	Provides a set of output load terminals for delivery of electrical energy to the customer's load circuit

Table A.27 *(continued)*

Attribute	**Context**
Supply regulation	Regulates the delivered electrical energy in accordance with available credit and the attributes of the configuration profile
Voltage protection	Optionally interrupts the supply to the load when the supply voltage is outside of the extended operating range, but within the limit range of operation, with programmable control over automatic restoration
Power_Limit protection	Optionally interrupts the supply to the load when a programmable power limit is exceeded, with programmable control over manual restoration
Integrity testing	Performs a predefined supply interrupt/restore test with activation from a token
Intrusion protection	Optionally detects unauthorized access to the sealed enclosure
Association	
Token_Carrier_Interface	a) Test tokens; b) Optional clear_Tamper tokens; c) Set delivery configuration profile tokens
User_Interface	a) Optional manual actuator lever; b) Optional test buttons
Accounting function	a) Available credit
Metering function	a) Optional monitoring of power measurements; b) Optional monitoring of voltage measurements; c) Optional monitoring of phase unbalance measurements
Display function	a) Indicator for the state of the load switch; b) Indicator for the status of the incoming metered supply; c) Indicator for the status of the delivered supply to the load circuit; d) Indicator for when supply interruption was due to the expiry of available credit; e) Optional indicator for when supply interruption was due to exceeding the programmed power limit; f) Optional indicator for when supply interruption was due to exceeding the extended voltage operating range; g) Display of the registers contents; h) Markings on the nameplate and terminal covers and optionally on the user interface
Security function	a) Sealing of terminals; b) Sealing of the delivery function components; c) Protection of the connection and data exchange protocol between parts. d) Protection of access to the cable entry points; e) Protection against influence from external sources; f) Protection against malfunction; g) Failure mode under a combination of influence quantities; h) Protection against magnetic fields; i) Limitation of random and wilful activation by the user; j) Protection of access to the register contents; k) Protection of data integrity; l) Detection of tampering
Recording function	a) Delivery_Configuration_Profile; b) Load switch status; c) Delivery equipment serial number
Test function	a) Test for the correct operation of the load switch

A.9.2.1 Supply interruption and restoration processes

The delivered supply to the customer's load circuit shall be automatically interrupted upon expiry of available credit, subject to the control of the accounting function.

The delivered supply to the customer's load circuit shall be automatically restored upon replenishment of available credit by means of a physical token carrier, subject to the control of the configuration profile. If credit is replenished by means of any automatic process, then restoration shall also be subject to manual intervention. For example: the push of a button, the operation of an actuating lever, the entering of a code.

The delivered supply to the customer's load circuit shall be optionally automatically restored when the network supply is switched on, subject to the control of the configuration profile and the Tamper_Detection_Status. This option shall be subject to the purchase contract between the meter manufacturer and the supplier.

An optional programmable power limiting function shall be provided that will automatically interrupt the supply to the load circuit when the average power consumed, exceeds the limit. This function is not intended as a system protection feature and the option shall be subject to the purchase contract between the meter manufacturer and the supplier.

If a power limiting state is detected during a restoration attempt, the meter shall interrupt the supply to the load circuit immediately, then wait for approximately 30 s before restoration is re-attempted. If the power limiting state persists for 5 such attempts, the process shall lock out further attempts for approximately 30 min before resetting and returning to the start of the process.

When the supply voltage is outside the extended operating range, but within the limit range of operation the supply to the load circuit may be interrupted, provided that the meter shall automatically restore the supply to the load circuit when the supply voltage returns to within the extended operating range. This function shall be optional and be subject to the purchase contract between the meter manufacturer and the supplier. (The automatic restoration option is currently a specific South African requirement).

When a "test_Load_Switch" token is entered into the meter, the supply to the load circuit shall be interrupted for a period of not longer than 2 min after which automatic restoration shall take place, subject to available credit and control by the configuration profile.

A secure supply interface (set of terminals) for the connection to the incoming metered supply shall be provided if the delivery equipment is not integral with the metering equipment (i.e. multi-part installation).

A secure load interface for connection to the customer's load circuit shall be provided, according to the particular requirements of the purchase contract.

A.9.2.2 Display functions

A visible indication of the state of the load switch shall be provided. It shall unambiguously indicate when it is in the open and closed position.

A visible indication of the status of the incoming supply shall be provided. A dedicated lamp or an active display would be sufficient.

A visible indication whether the voltage is present on the load terminals shall be provided.

A visible indication shall be provided to indicate when interruption of the supply to the load circuit occurred due to expiry of available credit.

A visible indication shall be provided to indicate when interruption of the supply to the load circuit occurred due to exceeding the programmed power limit. The indication shall persist for as long as the supply to the load circuit remains interrupted.

A visible indication shall be provided to indicate when interruption of the supply to the load circuit occurred due to exceeding the programmed voltage limits. The indication shall persist for as long as the supply to the load circuit remains interrupted.

It shall be possible to display the contents of each register in a suitable format, by entering a special token, a code or by pressing a set of buttons.

For the markings on the nameplate and terminal covers, the requirements given in 5.12 of IEC 62055-31 shall apply.

A.9.2.3 Security functions

Provision for the sealing of all terminals shall be provided in accordance with the particular requirements of the purchase contract.

Provision for the sealing of the delivery function components shall be provided in accordance with the particular requirements of the purchase contract.

In the case of a multi-part installation, the interface, connection means, the communications protocol between the parts, and the contents of all the registers shall be not less secure than as if it were a single-part installation.

The supply cable entry and load cable exit shall be such as to minimize opportunities for vandalism and the electrical bypassing of the meter. The load switch may be single-pole and shall be adequately protected to ensure that interruption of the supply to the load cannot be prevented by external influences such as magnetic fields or by the insertion of foreign objects into accessible slots.

Protection shall be provided against malfunction due to the ingress of vermin, by conformal coating of any printed circuit boards that may be used.

No combination of influence quantities within the limits specified in this specification shall cause the meter to supply unmetered electricity, fail to interrupt the load on expiry of credit or execute unspecified load interruptions. It shall not be possible to influence the switching operation of the contactor by applying a readily available magnet on the outside of the case.

The user shall not be able to randomly interrupt or restore the supply to the load circuit at will.

Appropriate techniques such as CRC checksums shall be employed to ensure a high level of data integrity of all registers.

A.9.2.4 Recording functions

The Configuration_Profile shall record the parameters that control the behavioural characteristics of the delivery function. Some of these may be:

- voltage upper and lower limits;
- power limit;

- interrupt control profile that determines which of the monitored attributes will cause the load switch to interrupt the supply to the load;
- restore control profile that determines under which conditions the supply to the load may be restored, whether automatic or manual;
- manufacturing related details like serial numbers, manufacturer identifiers, date of manufacture, etc.

A load switch status register shall record attributes such as:

- whether the switch elements are in the open or in the closed state;
- the cause for the last interrupt;
- number of interrupts that occurred since last reset of the status register.

The status of the incoming supply shall be optionally registered.

The status of the delivery supply shall be optionally registered.

The status of the tamper detection element shall be optionally registered.

All information can be recorded either by an electromechanical register or an electronic non-volatile memory register.

The non-volatile memory shall have a minimum retention time of four months in the event of power supply loss to the unit.

NOTE Longer retention time of the non-volatile memory shall be the subject of the purchase contract.

It shall be impossible to clear any records during normal use, but it may optionally be capable of being cleared by means of a special token under strict management control policy.

If the delivery equipment is not integral with the Token_Carrier_Interface, then it shall be allocated a device serial number and be permanently recorded on the front panel of the device. The device serial number may optionally be recorded in the non-volatile memory.

A.9.2.5 Test functions

It shall be possible to test for the correct operation of the load switch by means of a “test load switch” token.

A.9.2.6 Data_Exchange function

A secure interface for the exchange of information with other functions shall be provided if such other functions are not integral with the delivery equipment.

A.9.2.7 Data elements

The individual data elements may be specified under this clause, but for the purposes of this example specification it will not be done here.

A.9.2.8 Type test requirements

The requirements given in clause 10 of IEC 62055-31 shall apply.

When subjected to environmental stress tests, a sample of pre-payment meters shall demonstrate satisfactory operation equivalent to at least 10 years of continuous field operation.

A.9.3 Accounting function

Table A.28 – Definition of the Accounting function

Attribute	**Context**
Name	**Accounting function**
Class	:= 9; belongs to the generic class = Accounting
Data Elements	
Accounting_Register	Balance (dynamic); content = available credit Increment with token credit Decrement with delivery measurements
Low_Credit_Warning_Level	Warning level for indication of low available credit
Methods	
incr_Accounting_Register()	Increment the register value with the included amount
decr_Accounting_Register()	Decrement the register value with the included amount
get_Accounting_Register()	Return the value onto the token carrier
clear_Accounting_Register	Clear the value to zero
display_Accounting_Register	Display the value on the payment meter display device
set_Low_Credit_Warning_Level()	Set variable with the value from token carrier
get_Low_Credit_Warning_Level()	Return the value onto the token carrier
display_Low_Credit_Warning_ Level	Display the value on the payment meter display device
Operation	
Account balancing	Calculates available credit as balance of delivered energy and credit transferred via tokens
Token crediting	Increments available credit in accordance with token credit received from the Token_Carrier_Interface
Consumption charging	Decrements available credit in accordance with delivered energy measurements from the metering function
Available credit publishing	Makes the available credit available for use by other functions
Association	
Token_Carrier_Interface	a) transfer_Credit tokens; b) clear_Credit tokens; c) initiate_Test/Display tokens
Metering function	a) Obtains measurements for calculation of consumption charges
Display function	a) Display of available credit; b) A means for reading the available credit with 0,01 kWh resolution; c) Optional warning indicator when a pre-programmed level of credit remains
Security function	a) Sealing of terminals; b) Sealing of accounting function components; c) Protection of the connection and protocol between parts; d) Protection of the available credit register contents; e) Protection against malfunction; f) Failure mode under a combination of influence quantities; g) Data integrity.
Recording function	a) Accounting register for record of available credit balance; b) Optionally device serial number
Test function	a) Simulated clear credit

A.9.3.1 Meter accounting process

The meter shall account in kWh units for delivered electrical energy and for token credit in kWh units.

The available credit shall be continuously calculated as being the difference between the sum of payment credits represented by token credit and the sum of delivered energy debits as measured by the metering function and representing the amount of consumed electrical energy.

In the event that the delivery function should fail to interrupt the supply to the customer's load circuit, further consumption shall decrement the available credit into negative values. The negative units shall be deducted from any new credit amounts being entered by means of a valid token.

When the available credit reaches a predefined level, an optional warning indicator shall give an appropriate signal to the user on the user interface.

A.9.3.2 Display functions

Available credit shall be indicated on a numeric display and shall also indicate if more units are available than can be displayed, for example, by displaying all the numerals 9.

Optionally a low level warning indicator shall be provided that activates when a pre-programmed quantity of available credit remains. It shall be possible to display the pre-programmed value, which shall be invoked by means of a suitable token.

A means for reading the available credit with a resolution of 0,01 kWh shall be provided for testing purposes.

A.9.3.3 Security functions

Provision for the sealing of any terminals shall be provided in accordance with the particular requirements of the purchase contract.

Provision for the sealing of the accounting function components shall be provided in accordance with the particular requirements of the purchase contract.

In the case of a multi-part installation, the connection means and the communications protocol between the parts, and the contents of the accounting register shall be not less secure than as if it were a single-part installation.

Protection shall be provided against malfunction due to the ingress of vermin, by conformal coating of any printed circuit boards that may be used.

No combination of influence quantities within the limits specified in this specification shall cause the meter to supply unmetered electricity, fail to interrupt the load on expiry of credit or execute unspecified load interruptions. Appropriate techniques such as CRC checksums shall be employed to ensure a high level of data integrity of all registers.

A.9.3.4 Recording functions

As a minimum requirement the pre-payment meter shall store the available credit to non-volatile memory at intervals of not greater than 25 kWh. This requirement shall be in addition to any other storage mechanisms that are employed.

The available credit shall be recorded to a resolution of at least 0,01 kWh.

The meter shall have a storage capacity for available credit of at least 10 000 kWh.

It shall be possible to enter token credit amounts by means of a single token entry of at least 6 000 kWh.

The optional low credit warning level value shall be set by means of a token and be stored in secure non-volatile memory.

All information can be recorded either by an electromechanical register or an electronic non-volatile memory register.

The non-volatile memory shall have a minimum retention time of four months in the event of power supply loss to the unit.

NOTE Longer retention time of the non-volatile memory shall be the subject of purchase contract.

It shall be impossible to clear any records during normal use, but it may optionally be capable of being cleared by means of a special token under strict management control policy.

If the accounting equipment is not integral with the Token_Carrier_Interface, then it shall be allocated a device serial number and permanently recorded on the front panel of the device. The device serial number may optionally be recorded in the non-volatile memory.

A.9.3.5 Test functions

For testing purposes, a means of reading the available credit balance to within a resolution of at least 0,01 kWh shall be provided.

Optionally a special token shall cause the available credit to temporarily clear to zero for the purposes of emulating the expiry of available credit.

A.9.3.6 Data_Exchange_function

A secure interface for the exchange of information with other functions shall be provided if such other functions are not integral with the accounting equipment.

A.9.3.7 Data elements

Table A.29 – Definition of the Accounting register

Attribute	**Context**
Name	**Accounting register**
Structure	Units: kWh Integer part: 5 digits minimum Decimal part: 2 digits minimum
Context	Record of available credit
Associations	None
Access mode	Read and write
Triggers	Not compulsory

A.9.3.8 Type test requirements

The requirements given in clause 10 of IEC 62055-31 shall apply.

When subjected to environmental stress tests, a sample of pre-payment meters shall demonstrate satisfactory operation equivalent to at least 10 years of continuous field operation.

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