Plant Numbering System

Draft version 1.5. August 12th 2016

Function codes slightly updated compared to version 1.4 from September 20th 2013.

Not updated yet to the newest version of the Max-i fieldbus!

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Notice of use and Disclaimer

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Glossary and Word Definitions

The following definitions apply to all parts of the specification:

The word **shall** indicate a mandatory requirement to be strictly followed in order to conform to the standard. **Shall** equals **is required to**.

The word **should** indicate that, among several possibilities, one is recommended as being particularly suitable, without mentioning or excluding others; that a certain course of action is preferred, but not necessarily required; or, that in the negative form (should not) a certain course of action is deprecated, but not prohibited. **Should** equals **is recommended that**.

The word **may** indicate a suggestion, a possibility or a permissible action within the limits of the standard. **May** equals **is permitted to**.

The word combination **must only** is similar to **shall only**. **Must only** equals **is only allowed to**.

Acronyms and Abbreviations

BCD	Binary Coded Digit
BOM	Bill of Material
CAN	Controller Area Network
COM	Component Object Model
DCOM	Distributed COM
DEP	Design and Engineering Practice
DSP	Digital Signal Processor
EIS	Equipment Identification System
ERP	Enterprise Resource Planning
HMI	Human Machine Interface
HTML	Hyper Text Markup Language
IDE	Identifier Extension
IPv4	Internet Protocol Version 4
KKS	Kraftwerk Kennzeichen System
MAC	Multiply and Accumulate
Max-i	Multiple Access Cross-coupled Interface
MES	Management Executing System
MIS	Management Information System
NORSOK	The competitive standing of the Norwegian offshore sector.
OLE	Object Linking and Embedding
OPC	OLE for Process Control
OPC DA	OPC Data Access
OPC DX	OPC Data Exchange
PCS	Process Control System

PLC	Programmable Logic Controller
PNS	Plant Numbering System
RB0	Reserved Bit 0
RB1	Reserved Bit 1
RTR	Remote Transmission Request
SCADA	Supervisory, Control And Data Acquisition
SMS	Short Message Service
VBA	Visual Basic for Applications
XML	Extensible Markup Language

Introduction

1.1 Basic Idea

PNS is a new numbering system for process plants. There are more basic ideas of PNS:

- To create a numbering system where the machine numbers themselves contain enough information to enable communication with the various devices **by means of fieldbus systems and especially the fieldbus system Max-i**. It shall not be necessary with separate fieldbus addresses, cross-reference tables etc.
- To be able to number the various measurement types like temperature, pressure, level, flow etc. as properties of the equipment to with they belong like tank level and temperature, pump pressure, pipe flow etc. instead of using gauge names. This makes it much easier to overlook the process control system. For example, production line PP2 may contain a tank - T9 (PP2T9) - with two level switches, which controls pump PP2P1. In a traditional instrumentation drawing, the two level switches will be named as level switches like for example PP2LG1 (level gauge 1) and PP2LG2, but in this way, it is only possible to tell that two level switches are controlling a pump. However, with PNS it is also possible to use function codes like for example PP2T9L1 and PP2T9L2. Now it is obvious, that two levels - L1 and L2 - of tank PP2T9 are controlling the pump. In the same way, the various gauges on a pipe or a tank may also be named as properties of the pipe or the tank like for example PP2WL3F2 (water pipe 3 flow 2) and PP2WL3T1 (temperature 1).
- To be able to number all parts of the plant including spare parts with the same numbering system. It shall not be necessary with separate numbering systems for machinery, instrumentation, pipes etc.
- To be able to exchange data with all other systems.
- To make it possible to get a record of **all** components for example for flow gauge A1FG2 just by searching the documentation for this name (without the function code), so that it is not necessary to specify the use of a gauge. In for example numbering systems like DEP, which uses the ISO 3511 standard, the use of a gauge is specified by means of letters following for example F for flow, P for pressure, L for level, T for temperature and Q for **any** quality parameter like pH, density, power etc. (not specified). For example, the ISO number #FITBRQCSZA# means a flow indicator (I) and transmitter (T) with a status display (B), a recorder (R) and a totalizer (Q), which is used for control (C), switching (S), trip initiation (Z) and for an alarm (A). It is obvious that this number requires quite a number of bits and a great symbol on the drawing, and if just a small thing is changed like removing the alarm, all documentation, which contains this part, must be rewritten and redrawn. With the ISO standard, it is hopeless (with a normal search program) to search the documentation for equipment and components if the use is not known, because there are so many possibilities.

NOTE! This specification is only a first draft. Everybody is very welcome to send any comments and suggestions. The specification is primary based on experiences from feed mills and heating and power stations so there are without doubt many equipment types missing for other types of plants.

We are also very interested in other existing number systems (other than EIS, DEP, KKS and NORSOK).

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Background

2.1 Other Standards

Among other things PNS it is based on the following standards:

- S88.01 (ANSI/ISA-88.01) Batch Control standard (IEC 61512-1). This standard is used for batch production in for example the medical and the chemical industry.
- S95.01 (ANSI/ISA-95.00.01) Enterprise/Control System Integration standard. This standard is an extension of the S88 standard.
- ISO 3511 (ISA-S5.1 and DIN 19227, part 1). This standard is widely used for instrumentation.
- EIS. This standard is for example used on many breweries. It is partly based on the ISO 3511 standard.
- DEP. This standard is used in oil refineries, chemical and gas plants, exploration and production facilities etc. It is partly based on the ISO 3511 standard.
- KKS. This standard is for example used on all newer Danish and German power stations and many power stations in the rest of the world.
- NORSOK. This standard is used by the offshore oil industry.

The hierarchical structure of the various standards is shown below:

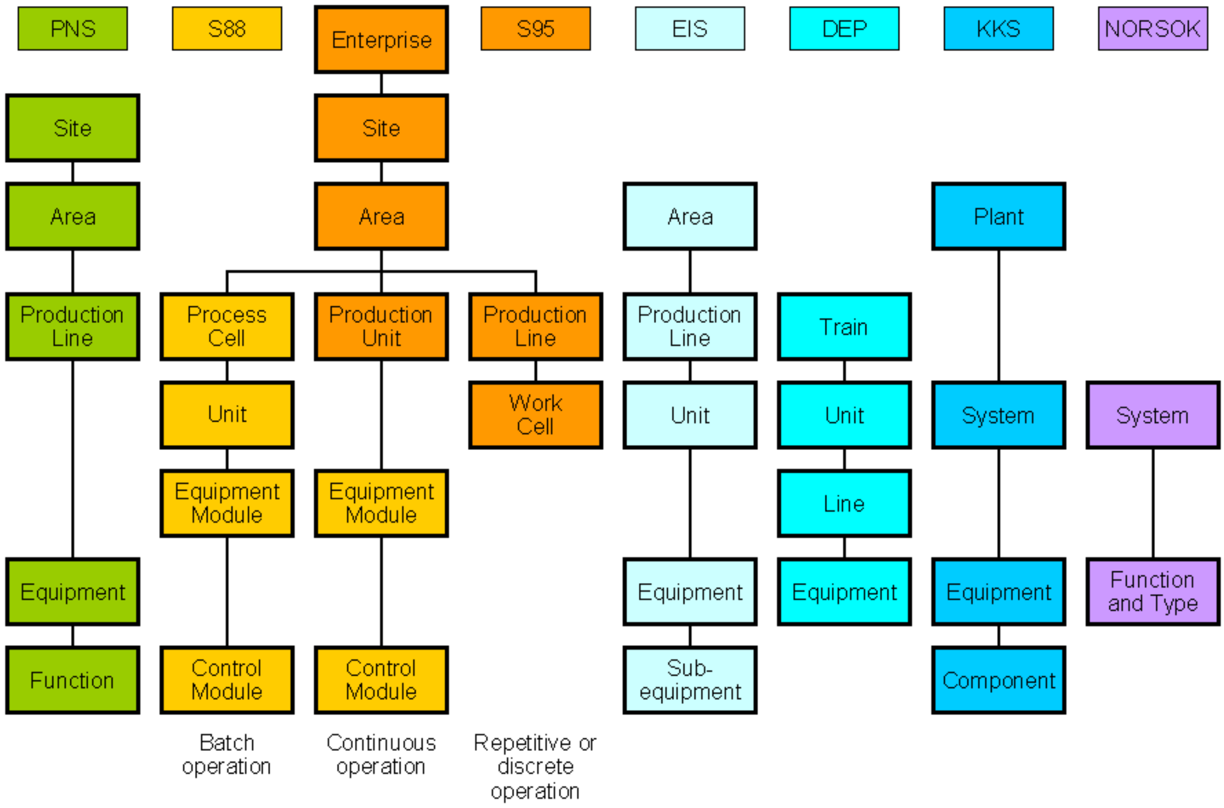

Fig. 2.1

NORSOK is divided into systems and equipments like KKS. It also has an Area specification corresponding to the Plant specification of KKS, but it is not a part of the tag code.

Note, that the designations of the S88 and S95 standards depend on the way of operation - batch, continuous or discrete. For example, a beverage manufacturer may have an area with a production unit for continuous mixing that feeds a process cell for batch processing that feeds a production line for discrete bottling process.

However, for a numbering system it is of course very impractical to use different designations in the same plant. In fact, the only difference between batch, continuous and discrete operation is that the batch size of a continuous process is infinite and the batch size of a discrete process is fixed. If for example the last stage of a batch process has a shutter (slide gate), which makes it possible to put the material in bags instead of a silo, it is in fact impossible to tell whether the process should be called a process cell or a production line because it depends on the position of the shutter. In the same way, if a hopper scale (batch) in for example a feed-mill is replaced by a continuous belt weight, it is no longer a process cell, but a production unit and the unit term no longer exist so all equipment has to be renumbered. Therefore, the designations of PNS are a general useable mix between the three operation modes of S95 and all the other standards.

Terms and Designations

3.1 Terms and Designations

Site. A geographical production site. The site specification is typical a shortening of the geographical location like for example AV for Avedøre. Site is another name for **Plant.**

Enterprise. A collection of one or more sites. The enterprise level is responsible for determining the products to be manufactured, on which sites they will be manufactured, and in general, how they will be manufactured. The enterprise is a part of the S95 standard, but it is not used in PNS. An enterprise specification has no meaning for a numbering system like PNS because there is only one enterprise.

Area. An area of a site like a block on a power station. The area specification is typical a number.

Process Cell. A logical grouping of equipment, which contains **all** physical entities required to make a certain product or one or more batches. A process cell may run one or more batches simultaneously. Process cells are defined at operational boundaries in the plant, for example, where a batch loses its identity because it is mixed with another material or batches or is used in further production.

Production Unit. The same as a process cell, but used in S95 for a continuous production.

Production Line. The same as a process cell, but used in S95 for a discrete production like a bottling process. Two of the biggest disadvantages of S95 are the many different terms for the same level and that a unit is not the same as a production unit, which is very confusing.

In PNS, production line is used as a common term for process cell, production unit and production line.

Train. An individual part of a process cell needed to make one or more parts of a batch. A process cell may have more than one train, and the order of equipment used to make a particular batch is called a **Path**.

Unit. A logical part of a train. A unit is typically centered on a major piece of processing equipment, such as a generator, a boiler, a mixing tank, a reactor, a mill, a pellet press, a silo group etc. In for example a feed mill, there may be six units - intake of raw material, weighing and dosing, milling, mixing, pellet pressing and delivery. The unit's primary defining requirement is that it can operate only on a single batch at a time. This does not mean that a batch must be in a single unit. In fact, during material transfers, a batch must be contained in at least two units. The last part of a unit is normally a storage element like a silo, a vessel or a tank, and in many cases, they are controlled by their own fieldbus so that an error on one bus does not affect the operation of other units. The units provide the major partitioning of the train equipment. They also are the major structuring elements used in recipes, because the major elements of master and control recipes in the S88 standard are organized as unit procedures. A good way of spotting a unit is by determining if a part of equipment must run a recipe or needs some information like the silo number in order to operate. If so, it is a unit. If not, it is equipment used by a unit.

Working Cell. The same as a unit, but used in S95 for a discrete production.

System. The same as a unit. Used in KKS and NORSOK. An example of a KKS system is HFE, which stands for "Air system for solid fuel boiler".

Line. A single conveying, processing, or driving line or chain within a unit like for example:

- A row of silos.
- A chain conveyor with shutters and two-way valves.

- A pipeline.
- A big equipment unit with its driving line likes for example a diesel engine, a turbine, a gearbox, a brake etc.
- An equipment module likes for example a filter with cleaning equipment and aspiration.

Equipment. A single process equipment within a line like a weight, a conveyor, a valve, a pump, a tank, a pipe etc.

Final Control Element. Used in S88 for those types of equipments, which are used to control the process like actuators, sensors, valves, pumps etc. In PNS and most other numbering systems, a final control element is regarded as the same as an equipment.

Control Module. A collection of final control elements, which acts as a single entity from a control standpoint like for example a control loop that operates via the set point. A control module has a direct connection to the various actuators and sensors. An example of a control module is a pump with flow control. Even though the control module exists in the S88 physical model, not all elements need be physical. For example, the PID controller can be a PLC instruction or DCS object and not a stand-alone device that physically links the flow gauge to the pump.

Equipment Module. A collection of control modules, which can carry out a finite number of minor processing activities, i.e., phases. An equipment module is able to receive high level phase commands like for example Circulate, Pump-to-Process, Stop, Shutdown etc. and generate high level status messages like Circulating, Pumping-to-Process, Stopped, Shutdown etc. An equipment module runs the same commands regardless of the product. The equipment module is a part of the S88 standard.

Function. A single equipment function like a motor current, a tank temperature, a pump pressure, a pipe flow, a start/stop function, the operation status, the operation mode (automatic/semiautomatic/manual) etc.

Component. A physical device, which is able to perform **one** I/O function like a pushbutton with lamp for the start/stop function or a rotary gauge for the operation status.

Attribute. A data storage location within a component, which is able to hold **one** value like configuration and calibration parameters, error word, vendor ID, type number and serial number etc.

Exchange of Data

4.1 Tiers

One of the most important properties of a modern process control system is the ability to exchange information between different systems and equipment from different manufacturers. This is for example one of the main reasons for using fieldbus systems.

A modern automation system may consist of three tiers:

ERP Sales and Distribution E-Business Supplier and Supply Chain Management Customer Management Finance and Book-keeping Prognosis and Budgets Assets and Liabilities Cash Flow Human Resources and Salary Resource Planning BOM Production Schedule *Time horizon: Months, weeks, days*
MIS and MES Warehouse Management Batch Management Tracking and Traceability Production Management Production Codes and Lot Numbering Production Analysis and Quality Control Production Reporting, Yield Data Historian *Time horizon: Hours*
PCS Material Managing Batch Execution Process Visualization / SCADA system Process Control / PLC's Actuator and Sensor Interface *Time horizon: Minutes, seconds, milliseconds*

Fig. 4.1

There are two standard ways of exchanging information between the different tiers - the old Microsoft way and the heterogeneous way.

The old Microsoft way is based on the object oriented programming model COM, which is the core of DCOM, ActiveX, VBA, OLE, OPC, OPC DA and OPC DX. However, these technologies are only usable on Microsoft platforms and they suffer from fairly high complexity and great difficulties with different software versions. With COM, all pieces of an application has to be deployed at once, so it is not possible to link in new applications dynamically.

The heterogeneous way, which is also used on newer Microsoft systems, is based on the Internet standards HTML and XML. HTML is the standard language for displaying information for **human** consumption. XML is the standard language for exchanging information for **automated** consumption. The benefit of HTML and XML is that these languages are very simple text based languages, which may be used on many different platforms and generated very easily. Unlike traditional method based systems, XML is self-describing with a name and description for each value and meta data telling how the telegram should be interpreted. It is therefore not necessary to have an exact number of arguments and to supply them in a precise order, so the various applications may be much looser coupled than with for example DCOM. Because each value has a name, XML fits perfectly together with fieldbus systems using the very efficient producer/consumer model like Max-i and CAN. On the other hand, all this extra information makes XML extremely inefficient. XML is hopeless to use **directly** on for example a fieldbus system. Therefore, one of the primary goals of PNS is to make a system, which will enable an unambiguous and loss less conversion between XML and an efficient fieldbus protocol.

4.2 XML Data Identification

A typical XML telegram for starting a fan for a solid fuel boiler and reading the hour counter of the fan may for example look like this (without any header and meta data):

```
<siteData>
   <siteArea name="Avedoere 3">
      <productionLine name="Solid fuel boiler 1">
         <equipment name="Fan 101">
            <function name="Command 1" value="10B"/>
            <function name="Time 1"/>
         </equipment>
      </productionLine>
   </siteArea>
</siteData>
```

This telegram fills 292 bytes plus any header and meta data just for transmitting one Boolean value and asking for one analog values. In a very fast high level Ethernet or FireWire (IEEE 1394) system or internal in a computer this may not be a problem; but for a fieldbus, it is of course much too inefficient although the telegram length may be reduced to almost the half by removing most of the space characters. Therefore, a loss less compression algorithm must be found. The first step has already been taken in the above example by combining the Site and Area specification (siteArea).

What the first part of the telegram actually does is to transmit the Boolean value 10B to the function:

Avedoere / Area (block) 3 / Solid fuel boiler line 1 / Fan 101 / Command 1

If the possibility in XML for using nested sites, areas, production lines, equipments and functions is not utilized, this information may be removed and added later on. This creates a fixed hierarchical structure of:

```
<siteArea>
   <productionLine>
      <equipment>
         <function
             attribute>
```

This may seem as a limitation, but practical experiences with for example DEP and KKS, which are based on a similar fixed structure has shown that this works very well in practice. Complex equipment like a filter may contain several smaller equipments like an air lock, a fan, a cleaning system etc., which could indicate the need for nested equipment, but in such cases, various equipments may just be grouped together by means of a common line number. Some numbering systems like KKS and DEP has a limited possibility for nesting, which makes it possible to number for example a motor, a diesel engine or a pump within an equipment. However, if an equipment is so big that it is important to number the various sub-equipments, it is usually also important to communicate with this equipment for example for reading the motor current or the pump pressure, but this possibility usually does not exist. It is only possible to access data and signals from the main equipment.

If attributes are needed for general data for the production line, the SCADA system must build a "soft" equipment and a "soft" function to hold these "soft" attributes, as it is not allowed to place a function directly under a production line. The name of the soft equipment should be the same as the production line (instead of for example Conveyor, Pump etc.).

By removing the nesting possibility the following general XML telegram structure is generated:

```
<siteData>
   <siteArea name="[name]">
      <productionLine name="[name]">
         <equipment name="[name]">
            <function name="[name]"
                     (attribute="[0-1023]")
                     (global-attribute="[0-7]")
                     (value="[value]")
                     (time="[time]")/>
            <function name="[name]"  .....  />
         </equipment>
         <equipment name="[name]">
                 .....
         </equipment>
      </productionLine>
      <productionLine name="[name]">
              .....
      </productionLine>
   </siteArea>
   <siteArea name="[name]">
           .....
   </siteArea>
</siteData>
```

Parameters in () are optional. For example, **value** (and **time**) is only specified if a value or attribute is broadcasted – not if it is polled. **Attribute** and **global-attribute** is used to read or write configuration or calibration parameter (global-attribute is write-only). If none of these is specified, the telegram contains a process value (default).

Unfortunately, XML is case sensitive, so that for example siteArea, SiteArea, sitearea and SITEAREA are not the same. In PNS, it has therefore been defined that all names shall start with a capital letter and all parameter designations like siteArea shall start with a lower case letter. The following letters shall be lower case letters except for the first letter in each part. The various parts should **not** be separated by means of signs like "-" or "_".

4.3 Standard Names

The next step in the compression process is to replace the names for the site, production line, equipment and function with codes exactly in the same way as it is done in most numbering systems. For example, in KKS the long system name "Air system for solid fuel boiler" is replaced with the much shorter "HFE", the equipment name "Fan" is replaced with "AN" and the component name "Pump motor" is replaced with KP. This standardization has the further advantage that it makes any language conversion very easy. If for example a system is delivered to Russia and is described with Russian letters in a non-ASCII text string it would be extremely difficult to debug for western personal, but with standard name codes it is possible to select **any** language without making any changes.

In PNS (and most other numbering systems), **all** codes consist of English Latin capital letters, that is, the letters A-Z.

4.3.1 Site, Area and Production Line

The site and area is specified by means of two letters for the site followed by a number in the range 1-8 for the area like AV3. The two-letter code is just a user-defined shortening of the site location like for example AV for Avedøre. If PNS is going to be used on a single area, the site and area specification may be omitted.

The production line code is a three-letter user-defined code for the name of the production line followed by a number in the range 1-99 like PP1 for pellet press line 1. This is the same as the KKS system code (described later), so that this code may be used.

4.3.2 Equipment Codes

The equipment codes of PNS consist of two letters (English capital letters). The letter O is not used since it may be confused with 0. There may also be a possibility for confusion between I and 1, but the most used fonts have a clear difference between the two. The **second** letter of the equipment code shall have the following definition:

Second letter	
A	Actuators like turning, driving, lifting, and slewing gear, motors, transmissions, manipulators.
B	Boilers, burners, heating, sterilization, and combustion equipment.
C	Conveyors, elevators, feeders, cranes.
D	Dryers, detoxication, and decomposition equipment, catalytic converters.
E	Electrical equipment, lamps, lighting, generators.
F	Filters with absorption/filter material.
G	Gauges like flow, level, pressure, temperature, current, voltage, pH, redox, gas, arc alarm.
H	Human machine interface (HMI) and panel devices like buttons, lamps, displays and safety switches.
I	Other equipment (user defined).
J	Junction boxes and racks, clamps, flanges, unions, connectors, hoses, electrical and optical cables.
K	Crushers, mills, grinders, presses, extruders and other size changing equipment.
L	Pipes, pipelines, tubes, and ducts links.
M	Mixers, agitators, breakers, coaters, dressers, nozzles.
N	Nuclear assemblies or user defined equipment.
P	Pumps, air compressors and blowers.
Q	Quick numbers for fieldbus communication.
R	Robots/NC, assembly, cutting, moulding, painting, welding, and drilling machines.
S	Separating and sorting equipment like screeners, magnets, centrifuges and expellers.
T	Tanks, vessels, basins, silos, columns, storage equipment.
U	Other equipment (user defined).
V	Valves, distributors, dampers, gates, rupture disk equipment.
W	Weighing and dosing equipment.
X	Heat exchangers, coolers, condensers, reboilers, fans, air condition.
Y	Tapping- and packaging equipment.
Z	Building parts and assemblies. Mobile units.

Fig. 4.2

Group I and U is used for user-defined equipment. The user should define the meaning of the first letter. If the plant is not a nuclear power plant, group N is also free for user-defined equipment.

Note that in the following a **single** letter equipment code refers to this **second** letter of the two-letter equipment code.

The codes for the **first** letter should have the definitions shown in the following. Note that while the **second** letter is a mandatory requirement of the standard, the **first** letter is only a recommendation and may be changed according to the present needs! Because group O is not used, the binary code for this is instead used to specify a one-letter code, which only consists of the previously defined second letter. This group always has the name of the main group like F for filters, P for Pumps, T for Tanks etc. It may be used if it is not necessary with a more detailed specification or in case of the Q code, which has no first letter.

Any unused codes may be used for user-defined equipment.

	Equipment = A	Equipment = B	Equipment = C	Equipment = D
A	Adjuster	Autoclave	Apron Conveyor/Feeder	Deaerator
B	Brake	Burner	Belt Conveyor	Biological Decomposer
C	Coupling	Combustion equip.	Chain/Wire Conveyor	Catalytic Converter
D	Diesel Engine	Distillation equip.	Discharge Feeder	Dehydrator
E	Electric Actuator	Electric Heater	(Bucket) Elevator/Excavator	
F		Furnace	Feeder	Freeze Dryer
G	Gearbox	Steam Generator	Grate	
H	Hydraulic Cylinder	Fired Heater	Hoist/Winch	Dehumidifier
I	Shaft			
J		Steam Ejector	Jog Conveyor/Tripper	
K	Manipulator	Kiln	Crane	Crystallizer
L	Lift		Table Feeder	
M	Electric Motor		Monorail, Cable Way	
N	Gas Engine			
	Actuator	**Boiler**	**Conveyor**	**Dryer**
P	Pneumatic Cylinder	Preheater	Pneumatic Conveyor	
Q	Bearing		Extractor/Singulator	
R	Roller Station		Roller Conveyor/Feeder	Rotary Dryer
S	Steam Turbine	Sterilization Funnel	Screw Conveyor	Spray Dryer
T	Gas Turbine	Toaster	Trolley	
U				
V	Vibration Damper		Vibration Feeder	Vacuum Dryer
W	Water Turbine		Wobbler Feeder	
X	Pneumatic Motor	Evaporator	Rotary Feeder/Airlock	Fluid Bed Dryer
Y	Hydraulic Motor	Flare		
Z	Silencer			

Fig. 4.3.1

	Equipment = E	Equipment = F	Equipment = G	Equipment = H
A	(Lighting) Arrestor	Air Filter		
B	Battery	Bag Filter		Button
C	Controller	Cartridge Filter		Card Reader
D	DC equipment	Drum Filter		Display
E	Earthing	Electrostatic Precipitator		Emergency Stop
F	Fuse	Filth Strainer	Flow Gauge	Fire Alarm Button
G	Generator	Gravelbed Filter	Test equipment	Gauge Indicator
H	High Volt. Switchgear			Horn
I	Insulator			Indicator
J				Joystick
K	Cathodic Protection			Keyboard
L	Lamp, Light Fixture		Level Gauge	Signal Lamp
M	Medium Volt. Switchgear	Micro Filter		Mouse
N	Navigation equipment	Nutsch Filter		
	Electrical equipment	**Filter**	**Gauge**	**HMI**
P	Protective Switch	Filter Press	Pressure Gauge	Keypad
Q		Fuel Filter		Quality Indicator
R	Rectifier	Reversed Osmosis		
S	Low Voltage Switchgear	Scrubber	Sight Glass	Safety Switch
T	Transformer		Temperature Gauge	Tag Reader/Scanner
U	UPS	Ultra Filter		
V	Vision system	Vacuum Cleaner		
W	Power supply	Wet Scrubber		
X	Filters, Compensation			
Y	Soft Starter			
Z	Converter			Light Grid/Curtain

Fig. 4.3.2

In PNS, there is a standard function (described later) for the most common measurement types plus seven empty spaces for user defined values. However, in a process there may be so many special chemicals that this is not enough. This is the reason for the gauge group (G). The user may just use any of the free letters, and then define his/her own function types. The standard functions only apply to the very few standard gauges. Unlike most other numbering systems, it is therefore possible to specify hundreds of different chemicals at the same time and in this way enable easy communication between different automation systems.

It is recommended to use the QG (Quality Gauge) as the first choice for chemical analysis and then define the function letters.

Actually, the gauge types FG, LG, PG and TG are superfluous as they may be replaced with standard function codes, but they are included anyway to enable a short form numbering without the function code for these very commonly used gauge types.

	Equipment = I	Equipment = J	Equipment = K	Equipment = L
A	User def.			Air Duct, Aeration
B	User def.	Bus Bar	Ball Mill	Blow-off Pipe
C	User def.	Clamp	Crumbler	Cable Duct
D	User def.	Data Communication Cable	Disc Mill	Drain Pipe
E	User def.	Low Voltage Cable	Extruder, Expander	Exhaust Pipe
F	User def.	Flexible Joint, Hose		Fuel Pipe
G	User def.		Granulator	Gas Pipe
H	User def.	High Voltage Cable	Hammer Crusher/Mill	Hydraulic Pipe
I	User def.		Impact Crusher	Inert Gas Pipe
J	User def.	Junction Box	Jaw Crusher	Hose
K	User def.	Connector	Cutter	
L	User def.	Optical Fiber Cable	Lump Crusher	
M	User def.	Medium Voltage Cable	Mill	Mailing Tube
N	User def.			Slurry Pipe
	User def.	**Union**	**Crusher**	**Link**
P	User def.	Power Outlet	Pelletizer/pellet press	Pipe
Q	User def.	Quick Connection	Grinder	
R	User def.	Rack	Roller Crusher/Mill	Refrigeration Pipe
S	User def.	Signal Cable		Steam Pipe/hose
T	User def.	Tele Communication Cable		Toxic Material Pipe
U	User def.			
V	User def.		Vertical Mill	Air Vent
W	User def.		Wash Mill	Water Pipe
X	User def.	Expansion Joint		Heating Pipe
Y	User def.	Pipe Penetration	Gyratory Crusher	
Z	User def.	Flange		

Fig. 4.3.3

	Equipment = M	Equipment = N	Equipment = P	Equipment = Q
A	Agitator	Absorber	Air Compressor	Not used
B	Blender	Breeder	Blower	Not used
C	Coater		Circulating Pump	Not used
D	Dresser			Not used
E		Burnable Absorber		Not used
F		Fuel Element	Fuel Pump	Not used
G				Not used
H	Homogenizer		Hydraulic Pump	Not used
I	Injector			Not used
J	Stirrer		Jet/Ejector Pump	Not used
K	Kneader			Not used
L	Liquid Adder		Lubricating Pump	Not used
M		Moderator		Not used
N	Mixing Nozzle	Neutron Source		Not used
	Mixer	**Nuclear Assembly**	**Pump**	**Quick Number**
P	Paddle	Plenum Assembly		Not used
Q				Not used
R		Reactor		Not used
S	Screw Mixer	Shield	Submerged Pump	Not used
T	Aerator Turbine			Not used
U				Not used
V	Mixing Valve	Reflector	Vacuum Pump	Not used
W	Humidifier			Not used
X		X-ray equipment		Not used
Y	Scum Breaker			Not used
Z				Not used

Fig. 4.3.4

	Equipment = R	Equipment = S	Equipment = T	Equipment = U
A	Assembly equipment			User def.
B	Bending Machine		Bin	User def.
C	Cutting Machine	Centrifuge	Column/HPLC	User def.
D	Drilling and Milling	Decanter	Drum	User def.
E		Expeller	Expansion Tank	User def.
F	Forming equipment	Fluid Bed		User def.
G		Cyclone		User def.
H	Handling Robot		Hopper	User def.
I			Interceptor	User def.
J				User def.
K			Cooling Tank	User def.
L		Liquid Separator		User def.
M	Moulding equipment	Magnetic Separator		User def.
N			Pressure Tank	User def.
	Robot	**Separator**	**Tank**	**Equipment**
P	Painting equipment	Purger	Pit	User def.
Q		Oil Separator	Sphere	User def.
R		Rotary Screen	Reactor	User def.
S		Screener, Sieve	Silo	User def.
T		Trap	Tank/Column Tray/Tier	User def.
U			Sump	User def.
V		Vibration Screen	Vessel	User def.
W	Welding equipment	Water Separator	Basin	User def.
X			Ion Exchanger	User def.
Y				User def.
Z		Chute	Container	User def.

Fig. 4.3.5

The code TT (Tank Tray/Tire) is used in case of big columns or tanks, which are (or may be) separated in various trays or tires. Each tray or tire may be regarded as a separate tank, which are vertical serial connected with other tanks to form a column. It is recommended that each column, which is divided into trays or tires, have its own line number, but it may be so big that it instead has each own unit number.

The TT code may also be used to enable more than for example 16 temperature measurements in a column or tank (described later).

	Equipment = V	Equipment = W	Equipment = X	Equipment = Y
A	Turnhead Distributor		Air Conditioning	Bag Applicator
B	Bleeder/drain Valve	Belt Scale	Reboiler	Bag Loader
C	Control Valve	Check Scale	Condenser	Case Packer
D	Damper			
E	Emergency Shutdown		Evaporator	
F	Fire Damper		Fan, Aspirator	Bag Flatening Belt
G	Slide Gate/Shutter		Grate Cooler	
H	Hand operated Valve	Hopper Scale	Heat Exchanger	
I				
J	Fire Hydrant			
K			Cooler	Cartoning Machine
L	Louvre	Loss-in-Weight		Loading Machine
M	Throttle Valve/Gate	Micro Scale		
N	Non Return Valve	Nuclear Scale		
	Valve	**Weight**	**Exchanger**	**Packer**
P	Purge Valve	Metering/dosing Pump	Heat Pump	Palletizer
Q	Sample/check Valve		Quench Cooler	Blister Packer
R	Reduction Valve		Refrigerator/Freezer	
S	Safety relief Valve	Scale		
T	Two-way Valve/Gate		Hot-water Tank	Tapping equipment
U			Floor Heating	
V	Vacuum Valve			
W	Sprinkler	Weigh Bridge	Waste Heat Recovery	Wrapping Machine
X	Explosion/Rupture Disk			
Y			Radiator	
Z			Cooling Tower	

Fig. 4.3.6

	Equipment = Z
A	
B	Barrier
C	Chute
D	Door
E	Elevator, Lift
F	Fire Door
G	Gate
H	
I	
J	Support
K	
L	Limiter/Flow Restrictor
M	Maintenance Equipment
N	
	Building Assembly
P	Port
Q	
R	
S	Solar Shielding
T	
U	
V	
W	Window
X	Fire Extinguisher
Y	Funnel, Spout
Z	Foundation

Fig. 4.3.7

4.3.3 Equipment Numbers

The equipment code is followed by a serial number with the number range 1-999 and an optional suffix letter - A, B or C - to indicate parallel operation. In those cases where the number of similar equipments (same equipment code) does not exceed 9 or 99, it may be practical to base the numbering on a digit hierarchy so that the most significant digit is used to indicate the unit or level. In for example a hotel, the most significant digit is very commonly used to indicate the floor so that room number 236 is room 36 on the second floor. In process control, the most significant digit may be used to represent the unit, the middle digit the line and the least significant digit the equipment number. An example of this is shown below with a silo group.

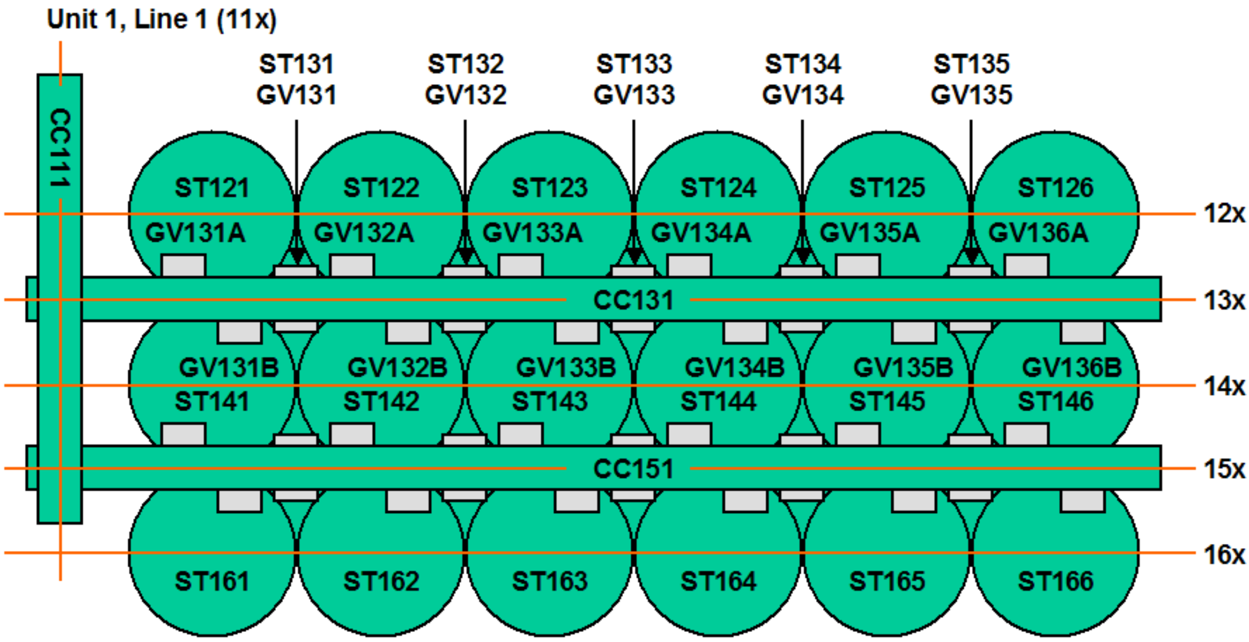

Fig. 4.4

In case of relatively small plants like feed mills etc. with only one production line, the equipment code and number may be enough to identify the equipment. For example in a feed mill, unit 1xx may be used for intake as the example above, unit 2xx for weighing and dosing, unit 3xx for milling, unit 4xx for mixing, unit 5xx for pellet pressing and unit 6xx for delivery. In this way, a very compact and intuitive numbering system is generated.

In the above example, the suffix letter is used to indicate parallel shutter valves so that it is easy to tell to which silo a valve belongs. The suffix letter may be very useful in many situations:

- To make it possible to use the same equipment numbers for more equipment as shown above.
- To indicate more equipment, which operate in parallel or redundant.
- To indicate two or three serial connected equipments of the same type, which operate simultaneously like two or three serial connected valves. This connection is typical used in safety systems to ensure that a single fault cannot lead to a dangerous situation.
- To make it possible to insert new equipment without destroying a consecutive numbering.

The use of the suffix letter is shown below:

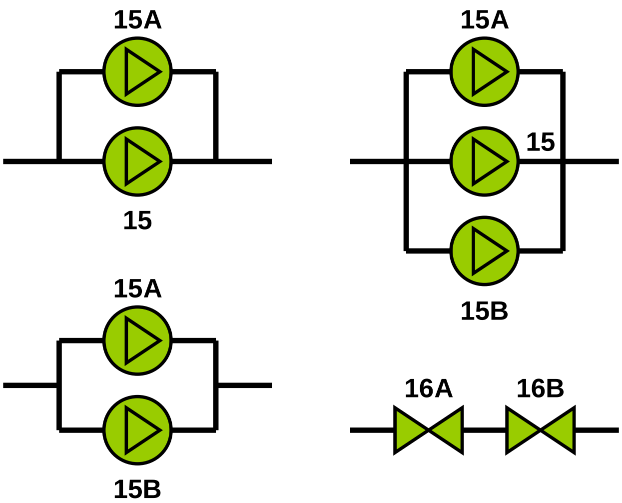

Fig. 4.5

In the case with three parallel equipments, the center equipment shall not use any suffix. It is like street numbering. The entry to the main street does not use a suffix letter, but an entry in the backyard do. If only two units operate in parallel or serial, they shall use the suffix A and B unless there is one main line and one side line.

4.3.5 Function Code

The function code or spare part number is the lowest hierarchical level of PNS. A function may be regarded as a communication channel between all transmitters and all receivers for that function. Most other numbering systems only has an equipment, a sub-equipment or a component specification as their lowest level, but this is not sufficient for communication. For example, it has no meaning to transmit a telegram with the content "Flow gauge number 1", "Push button number 4" or "Tank number 3". What is important is not the flow gauge, the button or the tank, but the actual flow value, the logical signal from the button and for example the level and the temperature of the tank. This is also the core of the producer/consumer model and XML. If a gauge has only one value to transmit, it may of course be possible to interpret the name of the gauge as that value. However, a gauge may have many sensors, and for example in case of a vortex flow gauge, which calculates the flow by measuring a pressure difference over a limiter orifice, it may also be able to indicate the differential pressure and perhaps the temperature of the medium. All these are functions - not components. Therefore, the most commonly used functions and measuring values like operation command, temperature, pressure, flow, level etc. has been standardized in PNS, so that it is possible to address these functions if a component supports them.

The function code consists of one or two letters followed by a number in the range 1-16. One letter is used for standard process values and two letters are used for used defined types. The standard values shall be:

Code	Binary	Type	Unit
A	00001	Alarm	Boolean
B	00010	Operation state (Auto, Hand, Initializing, Startup, Stopped etc.)	Boolean
C	00011	Command (Auto, Hand, Start, Stop etc.)	Boolean
D	00100	Density or specific weight	kg/l
E	00101	Error code	(no unit)
F	00110	Volume Flow	l/s
G	00111	Relative Position, Ratio, Gain	%
		Boolean position (Open, Closed, On, Off)	Boolean
H	01000	Humidity or Moisture	%
I	01001	Current	A
J	01010	Power	W or VA
K	01011	Time	s
L	01100	Level, Length or Expansion	m
		Presence of material	Boolean
M	01101	Mass Flow	kg/s
N	01110	Number or Quantity (counter)	(no unit)
		Keypad button (0-9 plus 6 more like * and #)	Boolean
P	10000	Pressure or Vacuum	bar
Q	10001	Volume Quantity	l
R	10010	Rotating Speed	RPM
S	10011	Speed	m/s
T	10100	Temperature	°C or °F
U	10101	Voltage	V
V	10110	Vibration and Acceleration	g
W	10111	Weight	kg
X	11000	Unclassified, Multivariable or User defined	(unknown)
Y	11001	Frequency	Hz
Z	11010	Emergency stop, Safety switch/signal, Fuse indicator, Alarm ack.	Boolean
* *	00000	User defined	user def.
* *	01111	User defined	user def.
* *	11011	User defined	user def.
* *	11100	User defined	user def.
* *	11101	User defined	user def.
* *	11110	User defined	user def.
* *	11111	User defined	user def.

Fig. 4.6

In case of a two-letter user defined code, the first letter shall not be A, B or C so that the code is not confused with a suffix letter followed by a one-letter code!

All values may (also) be Boolean. This is for example used in case of limit switches and feedback from the process. If for example the feedback signal for a motor comes directly from the motor starter, it should have the function code G. If it comes from a current sensor, the function code should be I, and if it comes from a rotary gauge, it should be R.

The function codes are very close to the **equipment** codes of the widely used ISO 3511 standard (used in for example EIS, DEP, KKS and NORSOK) except for a few, minor modifications.

- Group A, which was previously used for automatic initiated functions and alarms, is now used entirely for alarms since there is no need for a group for automatic initiated functions.
- Like ISO 3511, group B is used for process states like hand operation, auto operation, booting-up, initializing, stopped, pre-operational, operational, startup, running etc.
- Like ISO 3511, group C is used for Boolean commands like hand, auto, start, stop, right, left, open, close, clockwise, counter-clockwise, up, down etc.
- Group E, which is used for voltage in ISO 3511, is used for error codes.

- Group F has been split up to make it possible to distinguish between volume flow [l/s] and mass flow [kg/s] (group M). One of the major problems with ISO 3511 is that in many cases, the measuring unit is not defined or there may be more possibilities, so the value cannot be unambiguously converted to XML.
- Group G has been more explicit specified to relative position, ratio, gain and Boolean position. Relative position may for example be the opening of a valve, and Boolean position may be a fully closed or fully open signal or the position (state) of a motor contactor or motor starter. Absolute position in the form of a number like the floor level of an elevator or the position of a multi way distributor has been moved to group N. In ISO 3511, the letter G is also used for length, but this has been moved to group L, so that there is only one group with the meter unit.
- Humidity and moisture have been moved from group M to group H, so that Group M becomes available for mass flow. This is possible because there is no longer any need for a group for hand initiated functions.
- Group N, which is a user's choice in ISO 3511, is used for plain numbers without a unit like for example a floor level or a value from a counter. It may also be used for Boolean keypad inputs.
- Group Q has been split up in volume quantity (Q) and a (counter) value without a unit (N). Chemical quality analyzers use the user-defined codes.
- Group R has been redefined to rotation speed. In ISO 3511, it is used for nuclear radiation, but this function is so seldom used that it is more appropriate to use a user-defined code or a separate gauge type for radiation meters.
- Group S has been split up to make it possible to distinguish between speed (S), revolutions per minute (R) and frequency (Y).
- Group U, which is used for multi variables in ISO 3511, is used for voltage instead of E. Such types are moved to group X (unclassified) or to a user defined code.
- Group V, which was previously used for viscosity, is now used for vibration and acceleration. Like nuclear radiation, viscosity is so seldom measured that it is more appropriate to move this to the user defined group or a separate gauge type and instead use the V code for the much more common vibration measurements. Vibration measurements are used more and more in preventive maintenance to predict the lifetime of equipment.
- Like ISO 3511, group X is used for unclassified values. However, it may also be used for multivariables or a user defined function.
- Group Y, which is a user's choice in ISO 3511, is used for frequency, for example for frequency converters and generators. In ISO 3511, frequency is a part of group S.
- Like ISO 3511, group Z is used for emergency and safety acting. Group Z is also used for alarm acknowledge. In this case, the number of the alarm and the alarm acknowledge shall be the same.

If a gauge is separated from the sensor element, the sensor elements shall have the same name as the function it generates, and the name of the gauge shall be the name without function number or function specification! For example, a multi input gauge, which measure both temperature and pressure, may have the name G1. The sensor elements may then be called G1**T1**, G1**T2**, G1**P1** etc. In the same way, a level gauge on tank T15 with one or more external sensors may be called T15L (without function number) and the sensors may be called T15L**1,** T15L**2** etc.

A "-" followed by two letters and three digits is used to indicate a spare part like for example HK1-EM020, where EM020 is the spare part number of the electrical motor for HK1. Note that there may be many types of equipment, which use the same spare part, like for example HK1-EM020 and P2-EM020. When a spare part number is combined with the equipment number, the part gets a unique component number, which may be used on the drawings. If there are more spare parts of the same type on the same equipment like for example more 10 mm bolts, all these get the same number. This way of numbering is more convenient than the traditional serial numbering because there is no longer any need for a cross-reference table between component numbers and spare part numbers.

"H" is used (without number) to indicate a hand-operated equipment like 54QV2H for the hand-operated check valve QV2. To be able to use a short form notation without function code, the mostly used hand-operated equipment like valves also has a special equipment code (H) as for example HV for hand-operated valve. This code may be used if it is not necessary with a more detailed type specification.

In PNS, a negative analog value as for example a negative current, a negative power or a negative torque means brake current, brake power or brake torque. It is therefore not necessary with separate brake codes.

The two letter codes are user defined. However, it is recommended to use the following standard codes, if these measuring types are used:

Code	Type	Unit
EA	Cos(phi)	(no unit)
EB	Magnetic Inductance	T
EC	Capacitance	µF
EG	Conductivity	S
EH	Magnetic Field	
EI	Reactive Current	A
EJ	Reactive Power	W
EL	Inductance	Henry
ER	Resistance	Ω
MA	Angle	°
MF	Force	N
MT	Torque	Nm
LI	Light Intensity	cd
VI	Viscosity	cPs
DP	Differential Pressure	Bar
PH	pH	(no unit)
RX	Redox	
TS	Turbidity/Solids	
C1-C7	Extra Command Buttons	Boolean
T1-T7	Extra Temperatures	°C or °F

Fig. 4.7

The number range for functions is 0-15. This is assumed enough for the majority of equipments except for big columns or tanks, which may have a very high number of temperature measurements. However, in this case the equipment code TT (Tank Tray/Tire) may be used to separate the column or tank in more trays or tires, which can each have 16 temperature measurements. It is also possible to use the user defined function codes T1-T7. In this way, it is possible with up to 80 values of each type if there is no need for any other user-defined functions.

The user may select the numbers freely, but if he or she has no preferences, it is recommended to use the following standard for the first four values:

Number	Use
1	Common or total value, received command or setpoint, received output value, local sensor without transmitter likes a flow glass or a thermometer.
2	Actual process value or Boolean command
3	Controller difference, that is, the difference between the set point and the present process value.
4	Controller set point

Fig. 4.8

4.3.6 Attribute

The attribute number is new in PNS compared to the other numbering systems. It is included to make it possible to configurate and calibrate the components. For each I/O function, there are 1024 attributes where attribute 0-999 is used for user-defined attributes and the remaining 24 attributes (1000-1023) are used for standard configuration and identification parameters. Many complex equipments like variable speed drives and mass flow gauges typical require 250-500 setup parameters grouped together in logical groups by means of the most significant digit, so for such equipments, the full attribute range is needed.

To be able to program the attributes in consumers, they must of course have a unique identifier. In practice, this identifier is shared with a producer, which may be part of the same component like a push buttons with lamp. There is therefore always a producer for each consumer and the name of the component is identical to the name of the producer. In case of more control panels, the 1024 attributes must be shared between all producers of the same value. In this way, the attributes can be programmed individually for all components.

Identifier and Fieldbus Communication

5.1 Identifier

PNS is based on alternating numerical digits (n and N) and alphabetical letters (A). The total PNS identifier consist of 80 bits (10 bytes) as shown below:

Part	Site	Area	Production line	Equipment			Spare part	
				Number	Suffix	Code	Number	Code
b	AA	n	AAA NN	NNN	a	AA	NN	AAA
1	10 bit	3 bit	22 bit	10 bit	2 bit	10 bit	7 bit	15 bit

Part	Site	Area	Production line	Equipment			Function		Attrib.	Data type
				Number	Suffix	Code	Number	Code		
b	AA	n	AAA NN	NNN	a	AA	nN	A	NNN	bbb
0	10 bit	3 bit	22 bit	10 bit	2 bit	10 bit	4 bit	5 bit	10 bit	3 bit

Fig. 5.1

The Part bit determines whether the PNS number is a part number for the component or a function code for communication with the component. In case of a part number, the last part is the spare part number, so that the total PNS component number is a combination of the equipment number and the spare part number. The spare part number consists of two letters followed by three digits. The ranges for letters and numbers are:

A: A-Z,Æ/Ä,Ø/Ö,Å,Ü,-, **a:** -,A,B,C, **b:** 0-1, **n:** 1-8, **N:** 0-9, **nN:** 0-15, **NNN:** 0-1023.

The binary code for each letter (A) is the ASCII codes A-Z truncated to 5 bits, that is, 00001B for A or a, 00010B for B or b etc. The empty spaces are filled with the Swedish ASCII vowels for the Area and Train specification and filled with the two-letter codes for the function specification.

5.2 Max-i Fieldbus Communication

The equipment and function specification may be reduced to a 32-bit or a 16-bit identifier for communication on the Max-i fieldbus as shown below:

Local b	Equipment			Function	
	Number NNN	Suffix a	Code AA	Number nN	Code A
1 bit	10 bit	2 bit	10 bit	4 bit	5 bit

Local b	Quick number nNNN	111
1 bit	12 bit	3 bit

Fig. 5.2

The local bit is used to distinguish between local (1) and global (0) signals. Global signals are usually the signals, which shall be consumed by SCADA systems. In this way, a SCADA system can exclude fast local signals so that it will not be overloaded.

Because the last letter Z in the equipment code has the binary value 11010B, the equipment codes 111xxB are not used. This is utilized to distinguish between 32-bit and 16-bit addressing.

For fieldbus communication, the site and area specification is always omitted, and the production line specification is used to select the fieldbus. It is therefore not necessary to include the production line specification in the fieldbus identifier. Using the production line specification for fieldbus selection is also very appropriate for safety reasons, because an error on a fieldbus for one production line will not influence on other production lines. A production line should be able to work independent of other production lines.

The equipment number is placed in front of the equipment code to let the equipment number determines the telegram priority if PNS is used on a fieldbus systems like Max-i or CAN, which uses bit-wise bus arbitration. In the same way, the function number is placed in front of the function code to ease byte wide acceptance filtering in case less than 9 functions of each type is used – for example T0 – T7, but not T8 – T15.

5.3 Data Types

The three-bit data type, which corresponds to the data types of the Max-i fieldbus, has the following coding:

Code	Name	Application
000	FIXBCD	Fixed-point process value in BCD format
001	BCD	Floating point process value in BCD format
010	FLOAT	Floating-point process value
011	TIME	Time stamp
100	ASCII	ASCII (text) string
101	UNICODE	UNICODE (text) string
110	PATTERN	Pattern of bits, bytes and/or words
111	FIX	Fixed-point process value
Any	BOOLEAN	**Two-bit** Boolean value if possible

Fig. 5.3

In Max-i, all data types have a length of N × 8 + 2 bit where N is an integer, which may be 0. It is possible to use this either for one value – for example an 18-bit or 34-bit value - or for two values – one with the length N × 8 bit plus one 2-bit value. The latter may be used for Boolean values, which may or may not have supplementary data such as TIME, FIX or PATTERN. Max-i uses the telegram length to determine whether there are supplementary data or not. If the data type BOOLEAN is used in an XML telegram, which shall be transmitted, only a short telegram with 2-bit data is transmitted and if only a short telegram is received, the XML data type is specified as BOOLEAN. For systems, which are not able to handle a 2-bit data type, the data type PATTERN shall be used for Boolean values.

PNS has four data formats for process values – FIX, FIXBCD, BCD and FLOAT. These data formats shall only be used for values, which have been scaled and converted to metric values. If the data are not scaled, the data type PATTERN shall be used instead. For the moment the following standard units are recommended:

Unit	Name		PNS
Vibration/Acceleration		g	V
Temperature	degree Celsius or Fahrenheit	°C or °F	T
Length	meter	m	L
Level	meter	m	L
Weight and mass	kilogram	kg	W
Density	kilogram per liter	kg/l	D
Viscosity	centipoises	cPs	* *
Force	Newton	N	* *
Torque	Newton meter	Nm	* *
Expansion	meter	m	L
Pressure	barometric	bar	P
Time	seconds	s	K
Frequency	Hertz	Hz	Y
Rotating speed	Revolutions Per Minute	RPM	R
Volume flow	liter per second	l/s	F
Mass flow	kilogram per second	kg/s	M
Electrical current	Ampere	A	I
Electrical potential	Volt	V	E
Power	Watt	W	J
Work of energy	kilowatt hours	kWh	* *
Resistance	ohm	Ω	* *
Conductivity	Siemens	S	* *
Capacitance	microfarad	µF	* *
Inductance	Henry	H	* *
Amount of substance	mole	mol	* *
Humidity or moisture	percent	%	H
Luminous intensity	Candela	Cd	* *

Fig. 5.4

** indicates a two-letter user defined code as specified previously.

The units follow the SI Units (Système International d'unités) except for temperature, pressure, capacitance and work of energy, where the SI units Kelvin, Pascal, Farad and joule are impractical for process control applications. The temperature is either measured in °C or °F depending on the country.

5.3.1 FLOAT

The FLOAT data type uses the widely used ANSI / IEEE 754 32-bit single precision or 64-bit double-precision floating-point format. This format consists of three parts as shown below.

<table>
<tr><th>Sign</th><th colspan="2">Exponent</th><th>Mantissa fraction (significant)</th></tr>
<tr><td>1 bit</td><td colspan="2">8 bit (excess 127) or
11 bit (excess 1023)</td><td rowspan="2">23 bit or
52 bit</td></tr>
<tr><td colspan="2"></td><td>J</td></tr>
</table>

Fig. 5.5

The sign bit is used to specify the sign of the value. If it is zero, the value is positive, and if it is one, the value is negative.

The mantissa (significand) has two parts: A 1-bit binary integer (also referred to as the J-bit) and a binary fraction. The mantissa is shifted in such a way that the most significant 1 of the binary value becomes the J-bit. This is called normalization. Because the J-bit is always 1, it needs not to be specified. Therefore, it is an implied value in the IEEE format.

The exponent is the power of two needed to correctly position the mantissa to reflect the number's true arithmetic value. To facilitate comparisons among floating-point values, it is held in excess-127 or excess-1023 notation, which means that 127 or 1023 is added to the actual exponent so that the biased exponent is always a positive number. The reason for choosing 127 and 1023 is that the smallest normalized number can then be reciprocated ($^1/_X$) without overflow.

Because of the J-bit, the mantissa (without sign) of a normalized value is always greater than or equal to 1 and less than 2. Therefore, it is not possible to represent 0 directly, but if both the exponent and the mantissa is zero then the value is defined to be zero.

For very small values, it may not be possible to normalize the value because of the minimum value for the exponent. When the biased exponent is zero, smaller numbers can only be represented by making the J-bit (and perhaps other leading bits) of the mantissa zero. The values in this range are called denormalized (or tiny) values. The use of leading zeros with denormalized values allows smaller values to be represented. However, this denormalization causes a loss of precision. The denormalized values gives a gradual turn over from normalized values to zero, where all the mantissa bits are shifted out to the right by leading zeros.

The set of possible data values can be divided into the following classes:

- Zeroes
- Normalized numbers
- Denormalized numbers
- Infinities
- NaN (Not a Number)

NaNs are used to represent undefined or invalid results, such as the square root of a negative number.

The classes are primarily distinguished by the value of the exponent field, modified by the fraction. Consider the exponent and fraction fields as unsigned binary integers:

Class	8-bit Exponent	11-bit Exponent	Fraction
Zeroes	0	0	0
Denormalized numbers	0	0	non zero
Normalized numbers	1-254	1-2046	any
Infinites	255	2047	0
NaN (Not a Number)	255	2047	non zero

Fig. 5.6

The two infinities, + and -, represent the maximum positive and negative real numbers, respectively, that can be represented in the floating-point format. Infinity is always represented by a zero mantissa (fraction and J-bit) and the maximum biased exponent. The signs of infinities are observed, and comparisons are possible. Infinities are always interpreted in the affined sense; that is, -infinite is less than any finite number and +infinite is greater than any finite number.

Whereas denormalized numbers represent an underflow condition, the two infinity numbers represent the result of an overflow condition. Here, the normalized result of a computation has a biased exponent greater than 254 or 2046.

5.3.2 FIX

The IEEE floating point format is a widely used standard, but it is very difficult to generate and handle by means of simple low-cost hardware without a microprocessor. There are several reasons for this:

- Because of the implied J-bit, it is not possible to use a fixed exponent (denormalized numbers).
- Because the mantissa is a positive number plus a sign instead of a two's-complement number, it is not possible to offset compensate the value by means of a simple adder/subtracter, or by means of a simple preload of the pulse counter in case of a (synchronous) voltage to frequency A/D converter.
- It is not possible to use the data from an A/D converter directly.
- It is necessary with a special exception to handle the number zero.
- It is very difficult and time consuming to do digital filtering on the values, unless a special IEEE hardware floating-point unit is present.
- It has a fairly low efficiency for process control because 32 bits are needed even for measurement values with the usual industrial accuracy of approximately 12 bits.

Because of these disadvantages, PNS has the fixed-point data type FIX, which makes it possible for simple hardware based units to generate process values in SI-units.

The FIX data type consists of an 18-bit or 34-bit mantissa and a 6-bit exponent as shown below.

Mantissa	Exponent
N words plus 2 bit	6 bit

Fig. 5.7

The mantissa is a signed, left-shifted, two's-complement, fractional, 18-bit or 34-bit number in the range from -1 to $1\text{-}2^{-17}$ (18 bits) or -1 to $1\text{-}2^{-33}$ (34 bits).

The exponent is the power of two needed to correctly position the mantissa to reflect the number's true value in SI-units. It is held in excess-23 notation. If the exponent is 23, the value is equal to the mantissa. If the exponent is 24, then the mantissa shall be left shifted one bit, that is, multiplied by two. In the same way, if the exponent is 22, then the mantissa shall be divided by two. For example, the maximum positive, 18-bit, signed integer is 011111111111111111B = 1FFFFH = 131071. To regard a FIX18 number as a signed integer from –131072 to 131071, it is therefore necessary to move the radix point 17 bits to the right from 0.11111111111111111B to 011111111111111111.B. The exponent shall therefore be 23 + 17 = 40. In the same way, the exponent shall be

56 to regard a FIX34 number as a signed integer. If the extra two bits are not used in case of 16-bit or 32-bit words, the exponent must be reduced by two to regard the byte-aligned numbers as signed integers.

The number range for the 18-bit mantissa is approximately ±1 to $\pm 2^{-17}$, and the number range for the 6-bit exponent is 2^{-23} to 2^{40}. The total number range for a 24-bit FIX18 number is therefore $\pm 2^{-40}$ to $\pm 2^{40}$ or approximately $\pm 0.91\times 10^{-12}$ to $\pm 1.1\times 10^{12}$. In this way, the smallest normalized number can be reciprocated ($^{1}/_{X}$) without overflow ($1/2^{-40} = 2^{40}$). This number range also fit with industrial, electronic and scientific values where the smallest quantity is typical 1×10^{-12} (1 pico).

After commissioning, the exponent is fixed and do not change! It may therefore be implied in for example a fieldbus telegram. In this way, Max-i can transmit any process value in SI-units with an accuracy of 17 bit plus sign in only two bytes. This saves two bytes compared to the IEEE floating-point format! 17 bit plus sign corresponds to five digits (±99999). This is usually enough for the majority of process values as shown in the table below:

Type	Accuracy	
	%	Bits
Weight Load Cell Hopper Scale	 0.01 0.05	 14 11
Pressure	0.025	12
Temperature	0.1	10
Mass Flow	0.1	10
Volume Flow Liquid Gas	 0.5 1	 8 7
Level Pressure Radar	 0.05 1	 11 7
AC Current (RMS)	0.5	8
Conductivity	0.5	8
PH/Redox	0.5	8

Fig. 5.8

The table shows the absolute state-of-the-art accuracies.

Because FIX data are left shifted, it is possible to change the resolution of an A/D converter without informing the receivers. This is a **very** important property of the FIX format. It is even possible for a FIX18 consumer to accept FIX34 data and visa versa – just with a slight loss of accuracy. With right shifted data, it would be necessary to change the exponent if the resolution is changed to keep the values in SI units. It would therefore be necessary for the receivers to deal with a floating-point format**.**

The FIX format is extremely efficient for doing digital signal processing. In fact, it is both much faster and gives a higher accuracy than floating-point! This is how it works:

1. The amplification before the A/D converter is chosen in such a way that the converter range be utilized as much as possible and the total fixed-point number with the exponent is in SI-units. Note that the result of an A/D conversion is always a fixed number of bits - never a floating-point value - and in most cases, a left shifted number.
2. The exponent is fixed and saved for later use.
3. The mantissa is loaded **left shifted** (not right shifted) into the accumulator.
4. The required numbers of MAC instructions for the digital filter are executed. There are two ways to do this:

If the processor supports fractional arithmetic, both the value and the filter coefficient are regarded as 1.N two's-complement fractions, where the most significant bit is defined as a sign bit, and the radix point is implied to lie just after the sign bit. The range for an N-bit two's-complement fraction is -1 to $1-2^{(1-N)}$. A 1.N fractional multiplication generates a 2.2N result. To keep the radix point aligned the result is automatically left shifted one place. This may create a saturation if -1 is multiplied by -1, but in practice this saturation it completely unimportant as the result is very close to one ($1-2^{(1-N)}$). The following addition may of course create an overflow, but many digital signal processors like for example Blackfin from Analog Devices and dsPIC30F from Microchip use a 40-bit 9.31 fractional accumulator with 8 guard bits. Such an accumulator has a range of -256 to 255.99999999953 and is therefore able to handle any filter with up to 256 coefficients without any precautions. If there are no guard bits, the filter quotients can just be reduced so that an overflow never occurs.

If the multiplier does not use fractional arithmetic then the N x N integer multiplication generates a 2N result. Only the **most significant** half (high part) of this should be used in the further calculations. If for example two left shifted 24-bit numbers are multiplied in a 32-bit processor, the result is the most significant 48 bits of the 64-bit result, but only the most significant 32 bits are used.

5. The result is converted to SI-units by means of the saved exponent. Unlike the MAC operations, this only has to be done once.

Even though this method is much faster than floating-point arithmetic, it simultaneously has a higher accuracy. A state-of-the-art A/D converter has a resolution of approximately 24 bits, but with 1.31 fractional arithmetic, all intermediate calculations are done in at least 30 bits (2.30 fraction). With single-precision floating-point arithmetic in the IEEE 754 format, all intermediate results are rounded to 24 bits.

Signed and unsigned integers do not have their own data type, but use the FIX data type.

5.3.3 FIXBCD

The FIXBCD format is similar to FIX with a fixed embedded exponent, but all data are in BCD format, that is, all digits use their own 4-bit nibble (with the number range 0-9) as shown below. The FIXBCD format is primary intended for numerical displays like 7-segment displays driven directly by a fieldbus controller. Because the fieldbus Max-i has two extra bits, it is possible to handle a standard 4½-digit display (–19999) with an 18-bit FIXBCD and a 6½ or 8½-digit display with a 34-bit value. More than 8½ digits are not relevant for measurements and industrial control.

16 bit				**Optional 16 bit**				**2 bit**		**Fixed exponent**	
4 bit	**4 bit**	**4 bit**	**4 bit**	**4 bit**	**4 bit**	**4 bit**	**4 bit**	**2 bit**		**6 bit**	
MSDigit	Digit	Digit	Digit	Digit	Digit	Digit	Digit	**-**	**1**	**11**	Decimal point

Point	Data length	Number
0000	≥18	-1.9999(999999..) to 1.9999(999999..)
0001	≥18	-19.999(999999..) to 19.999(999999..)
0010	≥18	-199.99(999999..) to 199.99(999999..)
0011	≥18	-1999.9(999999..) to 1999.9(999999..)
0100	≥18	-19999.(999999..) to 19999.(999999..)
0101	34	-199999.999(99..) to 199999.999(99..)
0110	34	-1999999.99(99..) to 1999999.99(99..)
0111	34	-19999999.9(99..) to 19999999.9(99..)
1000	34	-199999999.(99..) to 199999999.(99..)
1001	>34	-1999999999.(9..) to 1999999999.(9..)
….	….	….

Fig. 5.9

Like FIX, BCD is left shifted. **No matter how many digits are used, the decimal point specification is the same and the data type only refers to this – not the number of bytes.** If for example a 6½-digit display receives a 34-bit value, the extra two digits may just be thrown away or used for rounding. If it receives fewer digits in case of an 18-bit value, the missing digits may just be shown as 0 or blanked digits. The last two bits of the data field are used for sign and “1” (½ digit). The sign bit is 0 for positive numbers and 1 for negative numbers.

5.3.4 BCD

The BCD format is similar to FIXBCD except that the first nibble is used to specify the decimal point (floating point). The decimal point specification uses the same coding as the four least significant bits of the FIXBCD data type specification except that all 16 possible point values may be used – not just up to 1000B so that values up to ±1999999999999999.(99…) (≥ 15½ digits) are possible in a 66-bit telegram (64 + 2 bit).

16 bit				Optional 16 bit				8 bit		8 bit		8 bit		8 bit		2 bit	
4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	4 bit	2 bit	
Point	MSD	Digit	Digit	Digit	Digit	Digit	Digit	Digit	Digit	Digit	Digit	Digit	Digit	Digit	Digit	**-**	**1**

Fig. 5.10

If the fieldbus Max-i is used, a telegram length above 34 bits is only possible in modem mode where the telegram may be any number of bytes.

If floating point BCD is not needed, it is recommended to use FIXBCD because of the higher safety, less risk of misreading (no floating point) and one more digit for a given number of words.

5.3.5 TIME

A time stamp uses three 16-bit words or two 16-bit words plus two bits as shown below:

XML							
Boolean	Year	Month	Day	Hour	Minutes	Seconds	Milliseconds
2 bits	10 bits	4 bits	5 bits	5 bits	6 bits	6 bits	10 bits

Max-i					
Day	Hour	Minutes	Seconds	Milliseconds	Boolean
5 bits	5 bits	6 bits	6 bits	10 bits	2 bits

Fig. 5.11

The two most significant bits may hold a Boolean 2-bit value. If a TIME value is transmitted on Max-i, the most significant word is omitted and any Boolean value is instead transmitted in the extra 2 bits.

Note that the time is counted directly in years (3 least significant digits), months (1-12), days (1-31), hours (0-23), minutes (0-59), seconds (0-59) and milliseconds (0-999). This is only a minor complication of the counter, but it saves many calculations later on. Day = 0 is used to indicate an invalid time.

5.3.6 PATTERN

This data type is used for all kind of patterns of bits, nibbles, bytes and words. Such data usually require a special knowledge for data interpretation and are therefore not directly useable as process values.

The data type PATTERN may for example be used for:

- Groups of binary or Boolean values.

- Raw data from A/D converters (may need scaling, offset adjustment, compensation for non-linearity's etc.).
- Arrays and records.
- Program files and memory dumps.
- Sound, picture and video data.

5.3.7 BOOLEAN

Devices, which support it, such as Max-i, may use compact **2-bit** BOOLEAN values as a supplement to the data type PATTERN, so that four states of a signal may be reported. This may be very useful in many cases:

- For landing/two-way light switching where it shall be possible to turn one or more lamps on and off from many switches. If only a single lamp shall be controlled, it is possible to use single-button (1-bit) monostable switches and a throw-over relay, but in case of more lamps, which are not driven from the same relay, this may lead to lack of synchronization so that some lamps turn on when other lamps turn off. Besides, it is not possible to send a command from a SCADA system to turn all lamps off or on. Instead, it is recommended to use two monostable switches programmed, which only transmits a telegram when they go on. This will course the telegram 10B to be send when the on-switch is pressed and 01B when the off-switch is pressed, but no 00B telegrams when the switches are released.
- For redundant signals in case of safety systems. 00B = off, 11B = on, 01B and 10B = error. Note that because of the required synchronization between the two signals so that a 01B or 10B state is avoided, this cannot be implemented with two separate signals, but requires a 2-bit signal.
- For anti-valence supervision where one bit is high while the other is low. If both bits are equal, there is an error.
- For driving lamps with up to four states – off (00B), slow flash (01B), fast flash (10B) and on (11B). With traditional point-to-point wired systems one signal is enough for flashing, but in case of a fieldbus system, it is highly impractical to send a telegram each time a flashing lamp should change state, and the unavoidable jitter may also cause an unpleasant flicker.
- For driving lamps and LED’s with two colors like off (00B), red (01B), green (10B) and yellow/both (11B).
- For controlling lamp dimmers – up (10B), no action (00B), down (01B) and on/off toggle (11B).
- For setting and indicating the mode of operation for an equipment, which may run in automatic, semiautomatic or manual/hand mode.
- For indicating the position of valves with two limit switches, but a common communication interface.
- For controlling equipment, which must maintain its position in case of a power failure like for example a shutter on a chain conveyor or a two-way valve. Such equipment is typically pneumatically activated and controlled by means of a four-way directional valve with two actuator solenoids - one in each end. Such a valve requires the two drive signals 01B and 10B and in some cases also a neutral 00B state. Without a two-bit signal it would be necessary first to deactivate one of the solenoids, then get an acknowledge signal that the command is received and at last activate the other solenoid. In a fieldbus system it would therefore be necessary with three telegrams instead of one, but in case of a fieldbus system like Max-i or CAN, which uses the producer/consumer model, the acknowledge is even impossible because the transmitter do not know the amount of receivers.
- For controlling two-way conveyors with three states - left (10B), stop (00B) and right (01B).
- For controlling motor operated control valves or other devices, which have an up signal (10B), a down signal (01B) and a passive state (00B).
- For controlling two-speed motors with three states - stop (00B), low speed (10B) and high speed (11B).
- For controlling contactors with more states like for example a star-delta starter or a 4-state Korndorfer starter - stop (00B), low (01B - autotransformer), medium (11B - autotransformer as serial coils) and full (10B - autotransformer bypass).
- For controlling two-way valves, which has a center position where the material stream is divided into two streams.

- For alarms with more priorities or for example a choice between a warning and an error.
- For two-level limit switches like for example low (01B), normal (00B) and high (10B).
- For making it possible with the same function name for a function with three or four states no matter if this is controlled by means of a toggle- or changeover switch or it is controlled by means of more monostable push-buttons. If only one-bit-values were used each of the monostable buttons should have its own function code, however this would make it impossible to name a changeover switch, because the name of the switch should then actually change after the position.
- For showing the progress of a command like for example stopped/closed (00B), starting/opening (01B), running/open (11B) and stopping/closing (10B).
- For making it possible for two gauges to work together on one signal, for example in case of big shutters with two limit switches with each a communication interface. One gauge has 0 as the most significant bit and therefore sends 00B and 01B, and the other has 1 as the most significant bit and therefore sends 10B and 11B.

Note that the two bits are just 4 states of the same status - **newer two different signals!**

5.3.8 ASCII and UNICODE

These data types are used for all kind of text strings in 8-bit ASCII or 16-bit Unicode. The ASCII type is also used for XML data.

5.4 Data Conversion to XML

When data are converted to XML, it is **not** necessary to specify the SI unit, the data type or the resolution. For example, the unit for mass flow is implied to kg/s, and therefore need not to be specified and the value is just the data shown as a floating-point number as shown below.

```
<function name="MassFlow 1" value="36.127"/>
```

Like a pocket calculator, an exponent is only necessary, if the data would otherwise be out of range. The value is the same no matter if the source data is in FIX or FLOAT format. The only difference is the number of digits, which depends on the resolution (FIX18, FIX34, FLOAT32 or FLOAT64).

With PNS, it is for the first time possible to expand a simple number on a drawing to a full XML telegram. If for example a button with the number AV8SFB2EH104 is pressed and time stamp is enabled (long telegram with the data type TIME) this may cause the following telegram in the MIS/MES system:

```
<siteData>
   <siteArea name="Avedoere 8">
      <productionLine name="Solid fuel boiler 2">
         <equipment name="Emergency stop 104">
            <function name="Command 1" value="11B" TIME="26.13:27:15.567"/>
         </equipment>
      </productionLine>
   </siteArea>
</siteData>
```

Note that in this case, a B suffix is added to the Boolean value to indicate that the value is binary and not decimal.

Of course, the XML conversion may be done at any time or even be omitted if the receiver understands the PNS codes. In this way, PNS is also very useful with low speed communication channels like a base band telephone line or in an SMS message on a mobile phone.

Compatibility with other Numbering Systems

6.1 Code Conversion

KKS, DEP and ISO 3511 are so worked in world wide, that it may be impossible to change these numbering systems - even to a better and more general-purpose alternative. However, a few simple rules make it possible to make an automatic and unambiguous conversion from these systems to PNS.

6.2 KKS Compatibility

KKS is based on alternating alphabetical letters - A - (English Latin capital letters other than I and O) and numerical digits - N - and is structured in plants, systems and equipment. KKS do not have a function code, but uses XYZ-signals instead as shown below:

Plant	System	Equipment		Component/ XYZ-signals
N or A	AAA NN	AA NNN (A)	-	AA NN

Fig. 6.1

The Plant specification of KKS can easily fit into the Site and area specification of PNS. The number ranges for the KKS system specification is exactly the same as the PNS production Line specification, so KKS fit directly into PNS.

KKS has an extremely bad utilization of the two-letter equipment codes, which in practice has made it necessary to use the most significant digit of the equipment number as a part of the equipment code like for example AA0xx for control valves, AA1xx for shut-off valves, AA2xx for hand operated valves, AA3xx for safety relief valves etc. This is not necessary with PNS, which has shorter and much more intuitive codes for this like for example CV for control valve and HV for hand operated valve. In many cases, the two-letter KKS equipment codes contain less information than the second letter alone of PNS! For example, the KKS letter code AT just means any cleaning, drying, filtering and separating equipment. It is not defined whether this is a filter, a screener, a cyclone, a magnet or any other possibility. As a comparison, PNS has 3x26 codes for these types of equipment! In the same way, the KKS code CE just means any electrical measurement. It is not possible to tell whether this is a current, a voltage, a power, a frequency etc.

Both KKS and PNS has a suffix letter code for parallel items, but to be able to squeeze the number into a 32-bit value, PNS only has three suffix letters where KKS has a full A-Z letter range. However, because the most significant digit of the PNS equipment numbers are not going to be used as extra equipment codes, this digit may instead be used as a line specification if four parallel lines are not enough.

The KKS component code contains a lot of redundant information and is therefore not used very much. Most of the information is also included in the equipment code as for example 3GCK10AP001-KP01 where AP001 is pump 1 and KP01 is pump motor 1. It is primary in case of nested equipments like a pump within a pump or a lubrication pump on equipment that the original KKS component codes are important, but in this case, the most significant digit of the equipment number may be used instead to group various equipments together. This also makes it possible to address functions in both the main equipment and the auxiliary equipments and in this way for example measure the lubrication pressure.

PNS has two letters and three digits (20 bit) for its component or spare part code, so all KKS component codes (17 bit) may also be used in PNS.

In many power stations, a two-letter, two-digits XYZ signal description code is used as a supplement to the KKS component code (KKS do not use X, Y and Z for the first letter). In this code, the letters - X, Y or Z - specifies the direction and type of the signal, and the second letter specifies the equipment type as in the KKS component code like for example G for a limit switch. However, as in the KKS component code this is usually redundant information since the equipment code already specifies this - except for nested equipment. The real signal information is in the two-digit number. For example, the XYZ code XG03 means greater than low-2, XG01 means greater than low-1, XG02 means greater than high-1 and XG04 means greater than high-2. This meaning is not obvious, so a big description table is needed.

The XYZ-signals corresponds to the function codes of PNS. Because the function code of PNS consist of one letter plus one digit and uses two-bit Boolean values it can contain more information than the real two-digit information in the XYZ-signals. It is therefore possible to convert the XYZ-signals to PNS by means of a conversion table and at the same time get a much more intuitive and easy to remember code.

In KKS, there are three different measurement codes - C for a direct measurement, F for an indirect measurement and D for the set point for a closed loop regulator. Previously controllers/regulators was a separate part of the process and therefore had there own (KKS) numbers, and the process was controlled by discrete inputs and outputs, but today many different equipments has build-in controllers and perhaps a direct fieldbus interface, which handles all I/O. Therefore a more general purpose scheme is needed. In PNS, this is handled by letting the number choose between the different possibilities. For example, function number 1 is always the received setpoint in case of a controller.

6.3 DEP Compatibility

DEP uses three different numbering systems as shown below - one for machine drawings, one for pipe drawings and one for instrumentation and control.

Machine drawing					
(Train) (N)	Equipment code A	(Support equipment) (A)	-	Unit NN	Equipment number NN(A)

1PD-7124 = Train 1, Unit 71, Pump 24, Diesel engine

Pipe drawing						
Pipe size NNN	-	Flowing medium A	Unit N	Line NNN	-	Piping class NNNNN

100-P7124-31011 = Process pipe, Unit 7, Line 124, Size 100, Class 31011

Instrumentation and control (ISO 3511)				
Unit NN(N)	Measured variable A	Functions A....	-	Equipment number NNN (A)

712PITBRQCSZA-004 = Unit 712 or 71, Pressure (P) indicator (I) and transmitter (T) 004 with status indication (B), recorder (R) and totalizer (Q), which is used for control (C), switch (S), trip (Z) and alarm (A)

Fig. 6.2

Note that the first letter "P" means three different things - pump, process and pressure!

In DEP, the line term is only used on the pipe drawings, but in the machine and instrumentation drawings, the second letter of the unit code may actually be interpreted as a line specification. If the last two digits of the line specification on the pipe drawings are simultaneously regarded as a pipe serial number (equipment number), then DEP comes quite close to PNS.

The instrumentation system uses two or three digits for the unit code, but digit number 3 is often equal to the first digit of the equipment number on the machine drawing, so it may be omitted. For example, if pressure transmitter 1 and pump 1 is located in unit 702, then the pressure transmitter is called 702PT001 and the pump is called P7021.

DEP has the same problem as KKS. It is possible to combine for example a pump (P) and its support equipment like a diesel engine (D) to the code PD, but again it is extremely seldom that an equipment is driven by so big an engine. If it is, it is more appropriate to specify the engine and the transmission as separate equipments and use a common line number to connect the equipments. This will enable communication with functions in both the pump and the diesel engine.

6.4 EIS Compatibility

The build-up of the EIS code is shown below:

Area	Train	Unit	Equipment	Sub-equipment
A	N	NN	A(A)(A) NN	A NN

Fig. 6.3

The number of letters in the equipment code depends on the equipment. Electrical equipment has one letter, instrumentation uses two letters - the first two letters of the ISO 3511 standard - and mechanical equipment has three letters. The mechanical code is a simple shortening of the equipment type like COM for compressor. In total, there are less than 60 codes, so the utilization of the three letters is extremely poor compared to PNS, which has 10 times more equipment codes with only two letters.

EIS has an A N NN NN specification for area, train, unit and equipment number where PNS has an N AAANN NNN specification for area, production line and equipment number. As can be seen, EIS easily fit into PNS.

6.5 NORSOK

In NORSOK there is a different Tag Code for almost all equipment like:

- Main equipment
- Pipes and lines
- Special items
- Manual valves
- Pipe supports
- Electrical equipment
- Instrumentation and Telecommunication
- Cables and junction boxes
- Fire and gas detectors

However, the basic build-up of the tag codes is:

System	Function and type code	Sequence Number	Parallel item
NN	A(A)	NNN(N)	(A)

Fig. 6.4

NORSOK do not have the same hierarchical build-up of as the other standards. For example, the tag code does not include an Area specification for dividing the facility, although NORSOK has such a code. NORSOK is therefore not able to handle parallel production lines very well.

The system specification is a predefined list of 90 (10-99) systems in the following groups:

00-09: Plant specific (user defined).

10-19: Drilling, well and subsea related systems like 11 for drilling process.

20-29: Main process systems like 24 for gas treatment.

30-39: Export and byproduct handling like 33 for oil storage.

40-69: Process support and utility systems like 50 for sea water.

70-79: Safety systems like 72 for fire fighting.

80-89: Electrical like 82 for main power < 1 kV.

90-99: Structural, civil, marine and architectural systems like 96 for subsea structure and template.

Because of the lack of hierarchy, the number range for the sequence numbers must be fairly big - up to four digits for pipes. The sequence numbers shall run consecutively within each system. It is therefore not allowed to put any hierarchical structure into this. This makes it impossible to convert a NORSOK number to PNS, although the equipment codes of PNS include most of the equipments used by NORSOK.

PNS Numbering

7.1 Rules

For basic equipment like a conveyor, a pump, a flow gauge etc., the site code and area number and the function code may be omitted on the drawings. For example, a pump may have the name A3P1 and the main part of a flow transmitter may have the name A1FG4. Any measuring value, component or equipment is then identified by adding the function code like for example A3P1P1 for pressure value 1, A1FG4F1 for flow value 1 and A1FG4U1 for (external) indicator 1.

The equipment numbers in each line shall increase in the direction of flow.

The most significant digit of the equipment code may be used to specify a line number. If a line is split up in more lines, at least one of the new lines **after** the splitting equipment should have its own line number. In this way, there will for example only be one chain conveyor with shutters in each line, so that it is easy to tell to which conveyor a shutter belongs. The new line number(s) shall start just after the splitting equipment, so that any interconnection pipes, spouts or ducts also gets the new number. Because all parts of splitting equipment have the same line number, the line may be regarded as an equipment module, which may perform high-level functions like Circulate, Pump-to-process etc.

If a line is split up in **identical** lines, for example if more pumps are operating in parallel, each of these lines shall either have a new line number or the suffix letter shall be used as explained before. The equipment numbers for the identical lines shall be the same. If there are more identical parallel production lines, the names and numbers of the equipments shall be the same.

7.2 PNS Examples

A few examples of the PNS numbers without site and area specification are shown below.

```
A6CE1         = Production line A6, Controller 1

A4P1          = Production line A4, Pump 1
A4P1C2        = Stop button 2
A4P1C3        = Start low speed button 3
A4P1C4        = Start High speed button 4
A4P1C5        = Auto button 5
A4P1C6        = Hand button 6
A4P1C2=00B    = Stop command 2
A4P1C3=01B    = Start low speed command 3
```

```
A4P1C4=11B   = Start high speed command 4
A4P1C0       = Received command
A4P1B1=xxB   = Actual running status
A4P1U1       = Motor contactor (unit) 1
A4P1G1=xxB   = Feed back from motor contactor 1
A4P1Z2       = Circuit-breaker/fuse 2
A4P1R1       = Rotary gauge 1
A4P1R1=xxB   = Feed back from rotary gauge 1
A4P1U3       = Local controller (unit) 3
A4P1B3=xxB   = OK signal 3 (from controller 3)

C2HK1        = Production line C2, Hammer mill 1
C2HK1C2=00B  = Stop command 2
C2HK1C3=01B  = Start command 3
C2HK1C0      = Received Command
C2HK1G1      = Feed back from motor starter
C2HK1R3      = Speed Set Point 3
C2HK1R0      = Received Set Point
C2HK1R1      = Actual rotating speed
C2HK1R2      = Speed Difference
C2HK1P1      = Pressure 1 for example lubricant
C2HK1T1      = Temperature 1 for example motor
C2HK1T2      = Temperature 2 for example bearing
C2HK1V1      = Vibration 1
C2HK1V2      = Vibration 2
C2HK1K1      = Operating time (seconds)
C2HK1N1      = Number of startups
C2HK1Z1      = Emergency stop button 1
C2HK1Z2      = Safety stop switch 2
C2HK1A1      = Fire alarm 1

F3AV1        = Production line F3, Distributor valve 1 (multi way)
F3AV1C2=10B  = Counter-clockwise start
F3AV1C3=00B  = Stop
F3AV1C4=01B  = Clockwise start
F3AV1N3=0010..0B = Position command 3 (example)
F3AV1N1=0100..0B = Position status (example)

A3EH1        = Production line A3, Emergency stop 1
A3EH1Z2      = Boolean value 2

E1AG2        = Production line E1, Alarm 2
E1AG2A1      = Fire alarm 1
E1AG2A2      = Fire alarm 2
E1AG2A0      = Summation alarm from equipment
E1AG2Z1      = Alarm acknowledge 1

P8CC1        = Production line P8, Chain conveyor 1
P8GV19       = Production line P8, Shutter 19 with two separate limit switches
               (A and B) with the same name
P8TV19       = Production line P8, Two-way valve 19 with combined limit switch
P8GV19C2=01B = Open command 2
P8GV19C3=10B = Close command 3
P8GV19G1=01B = Open from switch A (0xB)
P8GV19G1=00B = Not open from switch A
P8GV19G1=11B = Closed from switch B (1xB)
P8GV19G1=10B = Not closed from switch B
P8TV19C2=01B = Right command
P8TV19C3=10B = Left command
P8TV19C0     = Received command
P8TV19B1=01B = Right status
P8TV19B1=10B = Left status
```

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J9EG1        = Production line J9, Electrical gauge 1
J9EG1I1      = Current 1 for example high limit
J9EG1I2      = Current 2 for example high-high limit
J9EG1E1      = Voltage 1
J9EG1J1      = Power 1
J9EG1JE1     = Reactive power 1

A3QG1        = Production line A3, pH transmitter 1 with redox and temperature
A3QG1PH1     = pH value 1
A3QG1RX1     = Redox value 1
A3QG1T1      = Temperature value 1
A3QG1T1      = Electrode 1 for temperature 1
A3QG1T2      = Electrode 2 for temperature 2
A3QG1U1      = External indicator 1

L1TG8        = Production line L1, Temperature gauge 8
L1TG8T1      = External thermo element 1
L1TG8T1      = Temperature 1
L1TG8U2      = External indicator 2
L1TG8U3      = External indicator 3

L1TG3T0      = Production line L1, Thermometer without transmitter
L1B1SG1      = Local sight glass 1
L1B1SG2      = Local sight glass 2
L1B1T0       = Local temperature gauge without transmitter
L1B1P0       = Local pressure gauge without transmitter

L4FG2        = Production line L4, Flow Gauge 2 (vortex type)
L4FG2F1      = External restriction orifice for flow 1
L4FG2F1      = Flow 1 for example main flow
L4FG2F2      = Flow 2 for example high limit
L4FG2U1      = External indicator 1
L4FG2U2      = External recorder 2

S2QH1        = Production line S2, Quality indicator 1
S2QH1PH1     = pH value 1 from SCADA system
S2QH1RX1     = Redox value 1 from SCADA system

K1T23T1      = Production line K1, Tank 23, Temperature 1
K1T23U1      = External indicator 1
K1T22U2      = External indicator 2
```