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ENERGY SETTLEMENT. METER-BASED SETTLEMENT.

SYNOPSIS:

The aim of this report is to set a common Nordic standard for energy measuring equipment on board trains. This standard will then apply to the operators of railway traffic within the areas of the Norwegian National Rail Administration (JBV), the Swedish National Rail Administration (BV), the Finnish Rail Administration (RHK) and the Danish National Railway Agency (BS).

The following issues are described:

- Standard for energy meters on board new trains in each of the Nordic railway administrations areas.
- Standard for energy meters on board already existing trains in each of the Nordic railway administrations areas.
- Common rules for energy settlement with energy meters for border-crossing traffic Denmark – Sweden and Sweden – Norway

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The Nordic Technical Directors
JBV, BV, RHK and BS

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1. Introduction

The aim of this project is to produce a uniform Nordic standard for how power settlement using electricity meters on trains should take place and to prepare standard for measuring equipment.

The rail administrations in the respective countries are today responsible for buying electrical power for the operation of trains (does not apply in Finland). This responsibility also entails the task of distributing the cost of electricity purchases between the various train operators. The fairest way in which to distribute costs is to do so using electricity meters on board the trains. When ordering new locomotives, it is easy to have an electricity meter installed at a reasonable cost. However, it is both more expensive and more complicated to install electricity meters in existing locomotives.

The Nordic railway administrations agree that electricity meters will be in place in all locomotives in the future as new trains are delivered with meters already. Also the existing locomotives should have energy meters installed. The time schedule for installation of energy meters in these locomotives is up to each country to decide, it depends on how old the fleet are and when it should be replaced by new locomotives.

The participants in the project group were:

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2 Summary

This report deals with requirements for the equipment which will measure power consumption in the railways in the Nordic countries to facilitate the distribution of costs and to be able to measure the results of energy-saving measures.

The accuracy of measurement should be at least 2%. Existing measuring transformers should be used, if possible. If their accuracy class is poorer than that required to achieve 2% accuracy overall, there is no reason to replace them if the total accuracy is maximum 5%. They should still be used.

GSM-R and/or GSM should be used for automatically remote reading and measured data collection from locomotives to a central collection unit/invoicing system. The data format of these measured values should be compatible with EDI-EL, which is used throughout the electrical power sector. It should also be possible to give information to other systems, such as driver information.

If we use meters for billing, the information we get from the meters can be used to create new tariffs with for example power (kW) component. This matter is going to be solved in our billing system. The Meters shall not measure power factor and disharmonics but common rules for how we deal with power factor and disharmonics must be created. Consumption for train heating will be measured in this system only when the train is taking energy via pantograph. When the train is parked with connection to pre-heating equipment we can not measure that consumption with this equipment. It has to be taken care of in another way.

3 Tasks of the Project Group

The group is to produce common Nordic requirements for measuring equipment with regard to accuracy, crossing borders, reading off, format of measured values, etc.

4 Equipment for measurement of energy

4.1 General Requirements

The project group has agreed that, in order to measure power consumption on board trains, measuring equipment is required which should be as follows:

The measuring equipment must consist of an electricity meter capable of recording consumption each 5 min period with the possibility to show the consumption for variable periods up to one year. It must also include equipment for remote reading of the meter. The meter must record in both directions, i.e. regenerated energy must be registered separately. It must be possible to give information from the meter to other systems such as driver information. Interface and data format for this must be specified in the offer by the supplier of metering equipment.

The energy meter must be constructed in such a way that it cannot be manipulated by the transport operator or the train owner. Therefore, it cannot be an energy meter that receives signals via the train computer. It must be completely self-contained.

Tax authorities' demands for taxation of energy to trains differ from country to country even within EU. For example in Sweden there is at the moment no energy taxation for electricity or diesel fuel for railway trains. In Denmark they have a taxation on energy for railway traffic and Banestyrelsen (the Danish infrastructure holder) has claims from the Danish taxation authority on an accuracy of 2 %, if Banestyrelsen shall have the right to give its own account for energy taxation. Deutsche Bahn has for their measurement project TEMA chosen components that give a total accuracy class of 1.22 %.

In existing vehicles measurement transformers for voltage and current, which not are of class 0.5 ought to be possible to use if they are of reasonable accuracy, so that the total accuracy is 5 % or lower. The background is the high cost for installing of a new voltage transformer (high voltage means high cost for booth purchase and installation). For planned new vehicles the total accuracy shall be 1.22 % or lower which implies transformers/sensors of class 0.5 and meters of class 1.0 or better.

4.1.1 Environmental conditions

All components including mechanical components (if applicable), shall meet the requirements of EN 50155 "Railway appliances- Electronic equipment used on rolling stock". According to clause 2 of EN 50155, the equipment shall meet the requirements of

the classification T2. Evidence shall be proved according to the corresponding type certification, as described in EN 50155 clause 10.

All components shall resist dirt, dust, humidity, oil, fuel, shower water and shock.

According to EN 60529, Electrical components and connectors located in the railcar or machine room, respectively, shall meet the requirements of IP54, all other shall meet the requirements of IP65.

All components shall resist commonly used detergents and procedures.

Parts (including paint, rubber parts, plastic and other non-metal material) that get in contact with water, commonly used chemical (alkaline and phosphate) and mechanical detergents shall not be affected in their function nor their appearance by any means.

The supplier of this equipment must show information on accessibility and reliability and also deliver service instructions and assembly instructions. This information shall be included in the offer from suppliers.

4.2 Demands for supplier of energy meter

Following component is the components that the supplier of energy meters are responsible for.

4.2.1 Energy meter

The energy meter for measuring and billing electric energy consumption on electrical railway motor vehicles shall meet the requirements that follow:

- Accuracy classification: 1.0 (In accordance with IEC 1036)
- Certified according to the regulations on standards of the responsible national authority
- Gauged by an adequate inspection authority

Additional requirements:

1) Kind of instrument:

Energy meter that measures consumed energy and regenerated energy. The meter shall be able to measure both 50 Hz and 16,7 Hz

2) Connection:

Indirect connection via current and voltage transformers

Input Current: 50-2000/5/1 A

Voltage: 12-36 kV/110 V

The energy meter maximum power demand from current and voltage transformers must be included in the offer.

3) Data interfaces:

- 1 x optical (IR for laptop)
- 2 x electrical (RS232 or better)
- Display
- Counter interface

4) Power feeding

- The meter shall have the power feeding (110 V DC) from the locomotive and it will be power that works even when the train is not in ordinary use. And above that the meter must have a battery backup for at least one week. The supplier of energy meter must give information about maximum power in the offer.

5) Positioning

- The equipment shall include GPS for positioning of each vehicle. To be able to handle cross border traffic.

6) Miscellaneous

- The registration number of the motor vehicle (optionally: registration of the number of the train) shall be written to the load profile
- The memory capacity shall be sufficient to store a profile of at least 60 days (with recordings every 5 min)
- Additionally, the total real power consumption and the total regenerated energy shall be recorded. Therefore the EDI-EL format shall be used.
- The real-time clock shall include a battery buffer (power reserve > 360 days, accuracy +/- 5 ppm, life cycle of the battery \geq 8 years)
- The capacity of the battery must be so that it can handle a period of 60 days when feeding power is cut off without losing any data
- Electrical and optical interfaces according to EN61107

- The time interval of the load profile recordings shall be selectable (e.g 5 min, 15 min, 1 hour).
- It must be possible to programme the meter for different ratio of transformers. 50-2000/5/1 A and 12-36 kV/110 kV

4.2.2 Radio data transmission

The energy measuring device shall be equipped with a device for data transmission. The profile/logbook (completely or in parts), as well as the billing data shall be transmitted by using both GSM and GSM-R. The data shall be transmitted in the transparent mode, only, according to EN 61107, i.e. the data shall not be modified or processed by the use of an intelligent modem or a computer. The control station shall be able to communicate with the energy counter directly (readout of profile, logbook or billing data; time setting)

Specification of the radio data transmission

- GSM/GSM-R modem Transparent mode

The antenna for data transmission shall if possible be placed on the roof of each vehicle. If that is not possible the antenna shall be placed in the measuring box but the transmission conditions must be equal as if the antenna is placed on the roof. The owner of each vehicle decides where to place the antenna. If the antenna is placed outside the measuring box, the box has to have a connection point for a cable to the antenna.

See also chapter 4.3.2

4.2.3 Measuring box

The energy meter, modem, GPS and antenna shall be placed in a measuring box with the maximum size 475 x 306 x 100
(L x W x D)

4.2.4 Recording and remote reading of measured data

Reading every day is not necessary but recommendable to have a check of the function and thus in order to minimize loss of measured values. An energy supplier can have many tractive units that it is almost impossible to read every day/night. The units can be out of reach for GSM communication some times and therefore they can not be reached for remote reading. By use of remote reading with automatic calling up procedures, it shall be possible to reach the vehicle and collect the values of consumed energy.

Division of registers of energy between day and night because different energy prices is not necessary if the energy consumption is recorded on one-hour or quarter-hour base or other time base decided by the power supplier.

Claims for measurement for regenerated energy imposes use of double number of registers or two parallel meters.

Storing of measured values shall be done in format according to debiting system of EDI-EL (or in a compatible/synonymous format decided by the NIM-NES). This format is used as a branch standard within former Nordel (co-operation between the Nordic countries in electric energy exchange).

It must be possible to read meters remotely, as the number of electricity meters will be too large to handle manually when measuring equipment is installed in the majority of our trains. In order to ensure that no measured values disappear, the memory in the equipment should be able to store measured values for at least 60 days. However, it is possible that remote reading may not be necessary from the very start as the number of locomotives with meters will be limited. Remote reading may be done to advantage via GSM-R when this is well developed. However, other mobile networks may also be used. GSM-R is the

special mobile telephone network developed for the railways. It is already in operation in parts of Sweden. All trains will be fitted with a GSM-R telephone, which can then be used for measured value transfer.

If remote reading is out of order or before the billing system works it must be possible to read the meter manually and also with an PC to get all the recorded values. In that way we can temporary get values for billing without remote reading.

4.2.5 Switching between different power suppliers/countries

With meters installed on board trains, a problem arises when trains cross national borders or border between different power suppliers. The meter records electricity consumption even if the train crosses a national border or another border between power supplier with the same electricity system. Where it is necessary to change electricity systems, the train must have a meter that can measure in both electricity systems or be equipped with two meters, one for each electricity system. The metering equipment must automatically register when the train cross a border so it will be possible to tell how much energy that is consumed in each area/country. The equipment must be able to handle at least 10 different areas. For positioning GPS shall be used.

4.3 Demands for other equipment in trains for energy measurement

Following component is the components that the traffic operator is responsible for.

4.3.1 Measuring Transformers

The transformers to be used for measuring electric energy consumption on electrical railway motor vehicles shall meet the requirements that follow:

- Accuracy classification: 0.5
- Certified according to the regulations on standards of the responsible national authority
- Gauged by an adequate inspection authority

Additional requirements:

- 1) Voltage transformer (12-36 kV/110V)
 - with separate secondary winding for measuring energy
 - Maximum power demand for the meter 50 mVA in the circuit
- 2) Current transformer (50-2000/5/1 A)
 - with separate winding for measuring energy
 - Maximum power demand for the meter 0,5 VA in the circuit

Measurement transformers that are used in control system ought to be possible to use also for energy measurement (and if needed for Driving Advice Systems)

Measurement for different voltages and frequencies must be possible (15 kV, 16,7 Hz; 25 kV, 50 Hz). Only for vehicles that runs on different power systems.

4.3.2 Radio data transmission

The energy measuring device is equipped with a device for data transmission. The profile/logbook (completely or in parts), as well as the billing data will be transmitted by using GSM and GSM-R.

Specification of the antenna for radio data transmission

- Antenn	
Gain	≥0 dB (if installed on the roof) ≥3 dB (if installed in the motor vehicle)
Frequency range	GSM and GSM-R band
Transmission power	8 W min
Connection	N system (TNC, if designed as an integrated unit with the modem)
Impedance	50 Ohm (or according to the modems requirements)

This is the demands from the Deutsche Bahns TEMA system and they are not good enough in Germany

The antenna should if possible be installed on the roof of each vehicle, due to bad GSM signal in parts of the Nordic countries. If that is impossible the transmission conditions must be as good as if the antenna where installed on the roof of the vehicle. If GSM-R are used the ordinary GSM-R equipment shall be used for the metering equipment.

4.3.3 Power feeding

The operator must deliver power feeding (110 V DC) to the energy meter that still works when the train not is in use. Power demand approx. 5.5 VA.

4.3.4 Space for the equipment

The energy meter, modem, GPS and antenna will be placed in a box with the maximum size 475 x 306 x 100 (L x W x D)