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WELMEC

European Cooperation in Legal Metrology

Guide for Minimizing Fraudulent Use and Unintentional Misuse for Measuring Systems on Road Tankers

WELMEC

European Cooperation in Legal Metrology

WELMEC is a cooperation between the legal metrology authorities of the Member States of the European Union and EFTA.

This document is one of a number of Guides published by WELMEC to provide guidance to manufacturers of measuring instruments and to Notified Bodies responsible for conformity assessment of their products.

The Guides are purely advisory and do not themselves impose any restrictions or additional technical requirements beyond those contained in relevant EU Directives.

Alternative approaches may be acceptable, but the guidance provided in this document represents the considered view of WELMEC as to the best practice to be followed.

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Contents

1 Introduction

Modern road tankers as a category of measuring systems for liquids other than water are mostly a combination of metrological relevant parts and functional necessary parts, such as the hydraulic / pneumatic pipework, that make up the measuring system. The metrologically relevant parts of the measuring system shall comply with the EU-type examination certificate (EU-TEC) and shall be certified by the manufacturer respectively by the producer.

The number of involved parts and their complex arrangement and interaction make measuring systems on road tankers exposed to fraudulent use / unintentional misuse. Furthermore, due to the usage as a mobile measuring system and shared responsibilities the safe operation by minimizing the risk of unauthorized changes is an important issue. Finally, the consumer shall be sure, that the delivered quantity corresponds to the quantity to be paid, i.e. it is within the maximum permissible error (MPE) of the measuring system.

A number of Member States have noticed cases where road tankers have been fraudulently misused, favouring the delivering party. So the measuring system on a road tanker, although complying fully with OIML R117-1 edition 2007, might have features likely to facilitate fraudulent use and make unintentional misuse possible.

MID, ANNEX I - ESSENTIAL REQUIREMENT section 7.1 (“A measuring instrument shall have no feature likely to facilitate fraudulent use, whereas possibilities for unintentional misuse shall be minimal.”) commits manufacturers during the process of concept, development and construction of the road tankers to implement adequate measures against fraudulent use/unintentional misuse.

The considerations of this Guide focus on the prevention of fraudulent use and unintentional misuse. It does not focus on manipulations, which can be regarded as unauthorized changes of hardware or software (regulations against manipulation are outside the realm of MID), but on the design of the measuring systems which may have features likely to facilitate fraudulent use and unintentional misuse.

So, this Guide has been established to present guidance for a safe design as best practise, in connection with the requirements of OIML R117-1 edition 2007.

2 Scope

This guide refers to measuring systems for liquids other than water mounted on road tankers or on transportable tanks for the transport and delivery of liquids of low viscosity (≤ 20 mPa·s) and stored at atmospheric pressure, with the exception of foaming potable liquids according to OIML R117-1 edition 2007 section 5.2.

This guide is meant for the benefit of manufacturers and all other interested parties, e.g. notified bodies for module B, D, F, G and H1 of the MID, notifying authorities and market surveillance authorities.

This guide focuses on hardware components such as additional devices, the liquid pipework and the control process logic. For an overview of the main components of the measuring systems and their functions and interactions see Annex A of this guide.

For guidance on software at least WELMEC guide 7.2, edition 2015 is recommended.

3 Definitions, abbreviations and symbols

The definitions of OIML R117-1 edition 2007 apply to this guide.

Abbreviations:

ECID	Electronic calculating-indicating device
EU-TEC	EU-Type examination certificate
MID	Measuring Instruments Directive (2014/32/EU)
MMQ	Minimum measured quantity
mrcl	Metrologically relevant communication line
MS	Measuring System
NB	Notified Body
PLC	Programmable logic controller

The term “gas” is used as the general term for “air/gas” or for “mixtures of air and gas”

4 Guidance for a safe design

4.1 General construction requirements

The MS shall be designed as such to allow the control of the measuring tasks when mounted to the road tanker.

4.2 Constituents of a measuring system on road tankers

A measuring system on a road tanker typically consists of the following parts:

- a meter
- a gas elimination device
- a transfer point
- a shut-off valve
- an electronic counter
- a full and/or empty hose
- a pump (optional)
- a filter (optional)
- hydraulic / pneumatic pipework

The locations for sealing and markings should be arranged in such a way that they are easily accessible.
All sealing shall be documented in the EU-TEC and the accompanying document of the MS.
The constituents inside the cabinet of the road tanker should be neatly arranged, clearly visible and easily accessible; in order to check them they should be arranged in a sufficient distance to the walls of the cabinet.
The constituents outside of the cabinet of the road tanker shall be neatly arranged, clearly visible and easily accessible. Confusing and hidden arrangement of the hydraulic path shall be avoided. Unnecessary connections to the hydraulic path should be avoided.

The filter is used to protect the meter against parts and dirt in the liquid. The filter should have easy access for service and has not to be sealed. The filter has to be mounted upstream of the metering system. It may be combined with the gas elimination device.

Pumped systems operating as empty hose systems shall incorporate a non-return valve to prevent emptying the delivery hose or the reception tank caused by reverse flow. The non-return valve shall be secured against disassembly.

4.2.1 Pipework

The pipework shall, to the extent possible, be designed so that products cannot become mixed in the MS.
The MS should be designed in such a way that the varieties of setting the hydraulic paths are minimal.
The pipework should be arranged in such a way that it is visible as far as possible.
The pipework downstream of the meter shall not lead through a compartment.
Overfill prevention devices, located at the measuring system or at the filling tank, shall not affect the measuring result.
Different minimal diameters in the pipework should be avoided in order to avoid a Venturi effect.

4.2.2 Detachable couplings

Within a measuring system, easily detachable connections are permissible only as dry break couplings and should only be located:

a) at the nozzle of the full hose,
b) between a pump on the road tanker itself and the MS mounted on the semitrailer,
c) between the MS and a detachable supply tank on the road tanker,
d) between the MS on the road tanker and the supply tank on a trailer.

If case a) is present together with cases b) / c) / d), the design or the nominal size of the coupling in case a) should be different from the other case(s).

4.2.3 Performance and arrangement of pumps

Preferably, pumps should be of a not self-priming type.
Pmax of the pump should not be higher than Pmax of the other hydraulic parts of the MS. The pressure of the pump should not influence the performance of the MS. If this is not fulfilled, a depressurization device should be provided.
Care should be taken that the function of the used pump (reversible/not reversible, self priming/not self-priming) complies with the intended functions of the MS.
A reversible pump may suck liquid from the metrologically relevant part of the pipework back to the supply tank; adequate measures against that are non-return valves installed at appropriate sites (e.g. between the gas elimination device and the meter) and protected from being removed.
In order to support the evaporation of the suction side of the pump, the pump may be equipped with an ejector. The ejector should be appropriately protected against fraudulent injection of air into the liquid pipework. The protection measures should be capable of being secured.
The nominal diameter of the pump suction line should correspond to the nominal diameter of the gas elimination device and be at least equal to the nominal diameter of the meter.

4.2.4 Metrologically relevant communication and control lines

Metrologically relevant communication and control lines are:

- communication and control lines for the operation of the gas elimination device
- signal and control lines for solenoid valves
- signal lines of the pulser
- signal lines of the temperature sensor
- communication lines of the calculator

Metrologically relevant control lines are made of non-collapsible material. As an alternative, control lines can be used that remain deformed if tampered with.

The lines shall fulfil the chemical and physical requirements of the application and should be made of one piece. Lengthening of lines is not permitted; where this is not possible, a connection should be used which can be secured (i.e. junction box, connectors).

The lines should be clearly visible and arranged as single conduits, and as far as possible without crossings and excess lengths. Where they are fixed to the pipework, they shall be visible as far as possible.

The couplings of the lines on both ends shall be secured against removal by anti-tamper devices.

A pressure relief outlet (e.g. of a solenoid valve) shall be protected in such a way that it cannot be closed by the usage of tools.

Where the air pressure supply can be adjusted and affect the functioning of the measuring system, the measuring system shall be equipped with device(s) / valve(s) to ensure all components work within their rated operating pressure.

Electrical lines should be shielded and the shield should be connected to ground in accordance with manufacturer's instructions.

Branches and joints, which are not necessary for the intended use, shall be avoided. Interconnected components should only be permitted, provided that the component has a legally relevant function; the couplings of the lines shall be secured against modifications.

4.3 Rated operating conditions

The MMQ of a MS on a road tanker shall not be greater than 500 litres or kilograms.

4.4 Elimination of air or gases

Gas elimination devices shall be installed downstream of the pump. However, they may be combined with the pump.

Where functions of the gas elimination device are relevant for its intended use, which can be influenced from the outside (e.g. a reed-switch can be influenced by a magnet), appropriate shielding shall be provided.

If the housings of the filters, gas separators and special gas extractors are intended for draining, the draining devices shall be fitted with a non-return valve preventing the entry of air or gas into the housing during delivery. The non-return valve shall be designed to be protected against disassembly. If the meter sensor is being emptied, provisions are to be made to avoid an erroneous measurement after refilling the system.

For MS with an empty hose, which can be operated without pump, air/gas relief valves and gas removal pipes should have a non-return valve in order to avoid suction of air into the liquid.

Valves installed between the gas elimination device and the meter should not be capable of being set into an intermediate position.

4.5 Gas removal pipe

The gas removal pipe shall either lead to the atmosphere, to the top of the supply tank or to a spillage tank. In case of gravity discharge the gas removal pipe may be led downstream of the meter.

No means for closure of the gas removal pipe shall be available.

A gas removal pipe shall be made of non-collapsible material that its cross section cannot be altered by squeezing, cracking or other misuse. The conduit of a gas removal pipe should be clearly arranged. If the gas removal pipe incorporates a branch, it should not be possible during delivery to select the shut-off position.

4.6 Bottom valves

Bottom valves shall be operated pneumatically without any intermediate position. Mechanical means to open the bottom valves in case of an emergency shall not be provided.
The bottom valves of different compartments leading to the same MS should be fitted with an interlock against simultaneous operation, unless the system has been tested accordingly by an empty compartment test.
The outlet valve of a trailer's tank for the supply of the MS on a road tanker should be operated in the same way as a bottom valve of the road tanker.

4.7 Transfer point

In empty hose systems a venting device and a gas indicator shall be arranged downstream of the transfer point. The venting may be performed by blow-down with air pressure. In this case, the installation of a non-return valve must ensure that no measured product can be diverted through the air supply line. The valve must be secured against disassembly and removal.

For full hose systems the transfer point is at the nozzle at the end of the hose. This valve shall prevent the hose from running empty. A sight glass, normally combined with the valve, shall ensure that the hose is completely filled with product.

4.8 Complete filling of the measuring system

Where a reversible pump is installed, a non-return valve should be provided upstream of metrologically relevant parts of the pipework.

4.9 Branches and bypasses

The following options are available:

- metered full hose delivery
- metered empty hose delivery
- unmetered empty hose delivery

The delivery can be performed by means of a pump or gravity discharge. A change of the delivery outlet shall not be possible during a delivery. All deliveries, with the exception of unmeasured discharges through bottom loading couplings, shall be recorded. If there are couplings for unmeasured delivery on the suction side of the pump, it must be ensured that these are not used during a metered delivery.

A Change-over from one outlet to another one shall not be possible before the MS is set to zero.

Where measuring systems include two-way-valves, the latter shall not allow any intermediate position.

Draining between the meter and the transfer point shall not be possible.

4.9.1 Inlets and outlets of the liquid pipework and their interlocks

The pipework, valves and taps between compartments and measuring systems must be arranged in such a way that it is impossible to connect a measuring system to a tank separate from the road tanker.

In the following cases a metered delivery shall be interlocked:

- during an unmetered delivery,
- during refuelling the supply tank using the bottom valves,
- during refuelling the supply tank from a trailer's tank,

When the MS is located on a trailer, this applies to the trailer by analogy.

Devices for evacuation located upstream of the meter (no gas elimination devices) shall include a non-return valve which prevents entry of air.

4.9.2 Injection devices for additives

By the connection of an injection device for additives, no air shall enter the measuring system. So the injection should either be arranged upstream of a gas elimination device or downstream of the meter.

4.10 Accompanying documentation

The measuring systems shall be accompanied by a documentation containing the following information:

a) information about the measuring system
   - „Documentation of a measuring system on road tanker.....“,
   - manufacturer,
   - serial number of the tank,
   - year of construction,
   - type of pump, information on maximum flow rate and maximum pressure,
   - maximum diameter and maximum length of the full hoses,
   - markings on metrologically relevant components (in particular gas elimination device, meter and calculator)
   - space for notes in use:
     "If sealings are not broken and no changes have been performed on the measuring system, the verification of the measuring system is valid until…"
   - confirmation of the changes stated in the supplementary sheet (see e) and replacement of broken sealings
b) plan of sealings,
c) hydraulic pipework diagram,
d) functional diagram of the metrologically relevant control lines,
e) supplementary sheets including descriptions of changes, maintenance and repairs, and breaking of seals.

The documentation is part of the measuring system and shall be available on the vehicle at any time.

4.11 Meter

Meters shall be equipped with electronic calculators. An electronic temperature conversion is recommended.

4.12 Printing device and/or Memory device

According to MID, Annex I, 11.1 and 11.2, for MS on road tankers a printing device or a memory device is mandatory.

4.13 Conversion device

Parameters shall be protected against intentional and unintentional changes, such as: sort of products, product density, conversion formula incl. its parameters, parameters used for temperature measurement, etc.
Temperature sensors shall be placed so as to allow an easy in-use-control. A thermometer well shall be available in the liquid pipe close to the temperature sensor. Temperature sensors shall be sealed against removal and intervention.
The temperature sensor shall have a sufficient length so as to be placed into the liquid pipe in sidelong position, and a sufficient heat transfer from the liquid to the sensor shall be available.

4.14 Calculator

It shall be possible to display or print the metrologically relevant parameters.
A change of metrologically relevant data shall be recorded in a log-book. Alternatively, a seal counter is automatically incremented by 1 whenever relevant parameters are changed. For reference, a print-out of this log-book or seal counter shall be possible.

4.15 Checking facilities for the measuring device

The pulse output should be such that the pulse-counting unit is capable of registering the direction of rotation and act upon during reverse flow, which occurs over a certain period of time or a certain quantity of liquid. The quantity has to be counted with the correct sign.

5 Market surveillance

The measuring systems shall be designed so that they can be tested when mounted on a road tanker. The locations of the seals must be arranged in such a way that sealing and examination is possible without hindrance. The MS shall comply with the documentation according to 4.10. This documentation shall be available on the road tanker at any time.

6 Bibliography

- DIN 26053:2016-10 - Gesicherte Messtechnik an Tankfahrzeugen zur Auslieferung von Heizöl EL, Dieselkraftstoff und Biodiesel an Endverbraucher (Guidance for a safe design of road tankers)
- PTB-Anforderungen 5 (the former national German requirements)
- Directive 77/313/EEC of 5 April 1977 on the approximation of the laws of the Member States relating to measuring systems for liquids other than water
- Directive 82/625/EEC of 1 July 1982 adapting to technical progress Council Directive 77/313/EEC on the approximation of the laws of the Member States relating to measuring systems for liquids other than water
- OIML R117-1(2007) - Dynamic measuring systems for liquids other than water
- Directive 2014/32/EU of the European parliament and of the council of 26 February 2014 on measuring instruments

Annex A (informative) - Technical background

A.1 General

This informative annex shows the technical background of measuring systems on road tankers. MS on road tankers can include several different variations of hydraulic installations. They may

- serve different kinds of operation (delivery by gravity/pump/pressure, metered/unmetered delivery, emptying and filling of the compartments of the supply tank , full/empty hose operation),
- be equipped with different operational principles of gas elimination,
- have compartments which supply more than only one measuring system,
- be equipped with a control process logic for the automatic execution of the transaction,
- be affixed (in an unlimited number), either
    - to the road tanker itself or
    - to a trailer or
    - to a semitrailer,

  and the supply tanks may be fitted
    - to the road tanker or
    - to the trailer or
    - to the semitrailer,
- be equipped for loading the tank either from the bottom or from the top.

The keys of the schemes make reference to the requirements of OIML R117-1, thus giving the rational why and where a certain part of the measuring system has to be provided.
For the ease of the design/assessment process the study of these schemes is recommended.

A.2 Constituents of a MS on a road tanker

Usually, measuring systems on road tankers consist of the following components:

- Meter,
- The fixed tank of the road tanker comprising one or more compartments, each compartment with a bottom valve,
- A manifold for loading and unloading the compartments,
- Supply of the liquid either by a pump only, or by gravity only, or with the choice of either a pump or by gravity,
- Device which prevents to measure gas in the liquid (gas elimination device) or which corrects the delivered liquid volume for the entered gas,
- Gas elimination device.
- Liquid pipework with valves, inlets and outlets, to realize different kinds of operation modes, namely:
    - metered delivery via full hose and/or empty hose and device to prevent a diversion of measured liquid downstream of the meter. The number of delivery outlets is not limited, but usually there is one outlet via empty hose fed by gravity and by pump and one or two outlets via full hose fed by pump;
    - unmetered delivery (with or without pump);
    - loading of the vehicle’s tank by its own pump / by a remote pump, without passing through the meter;
    - loading of the vehicle’s tank by a bottom loading inlet;
    - delivery from a trailer’s tank over the meter;
    - pumping the liquid from a trailer’s tank into the vehicle’s tank and vice versa.

The operator selects the kind of operation using the control unit.

A.3 Process logic controller (PLC)

A process logic controller controls and monitors the transaction process, including the gas elimination device and valves setting the liquid path, depressurization vales, draining devices, sensors. The control and monitoring is done electronically or pneumatically.
The control and monitoring unit might be designed as a PLC unit, could be integrated in the ECID of the MS or designed as a hardware switching unit.

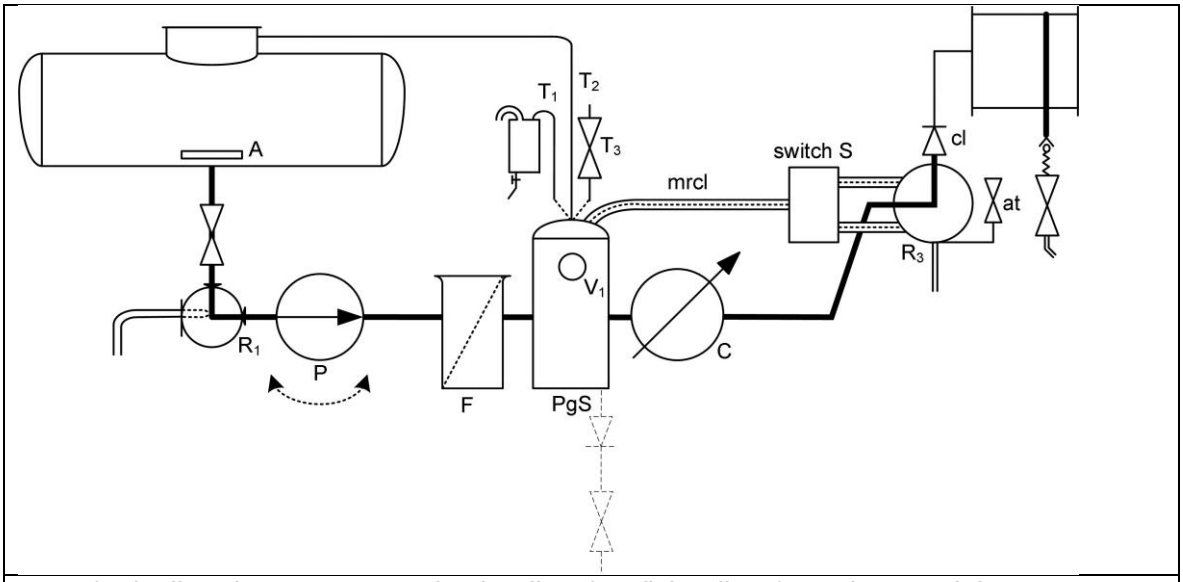
Functions of the process logic controller
It enables the operator to select different kinds of operation modes and to select the corresponding liquid path. It automatically interlocks different settings to prevent a mixture of products, set the correct outlet path and authorize a new transaction not before setting the indicating device to zero.
It automatically supervises the delivery process without the intervention of the operator e.g. in case of

- a MS with an electronic gas detection device: when gas is detected, the gas detected unit of the gas elimination function of the control logic triggers the closure of the valve in the delivery path until evaporation is finished;
- a MS with the meter installed in the outlet pipe which runs empty: when a sensor upstream of the meter registers the end of the liquid flow during a delivery, the control logic stops the registration of the measuring device. After a sensor at the outlet pipe has registered the empty state, the measured quantity is corrected correspondingly;
- a MS which prevents gas from entering the pipework: when a sensor registers that there is a risk that gas can enter the pipework during a delivery, the process control logic stops the delivery.
- a MS with gas bubble sensors: when gas bubbles are detected by a sensor during a delivery the process control reduces the pump speed, while another sensor registers the size of the air bubbles.

A.4 Types of gas elimination devices

The necessary kind of gas elimination device is subject to the supply conditions.
In this chapter different types of gas elimination are described. For all different types the communication lines are considered metrologically relevant, so they shall be protected against fraudulent use.
On road tankers the compartments are located higher than the level of the meter. During a delivery the pressure at the inlet is always higher than 1 bar. When the compartment runs empty, air is continuously introduced into the liquid. Gas elimination devices shall comply with these conditions.
Care shall be taken when the supply line has low spots beneath the level of the meter, where a vacuum may be generated. This could happen when the supply line from the trailer's tank to the measuring system sags. This arrangement is similar to a pump sucking liquid from a tank located below the pump level, where the tank runs empty. Much more air is introduced into the liquid, which can overwhelm the gas elimination device. For this reason a direct hose connection of a trailer to the measuring system has to be prohibited.

Special gas extractor
The special gas extractor reacts on air by closure and opening the delivery valve which depends on the amount of evacuated gas. During the evacuation of gas the valve automatically either stops or sufficiently reduces the flow of liquid to prevent the risk of gas entering the meter. In case of a shutdown, no measurement shall be possible unless the air or gases are automatically eliminated.



Metrologically relevant communication line (mrcl) leading from the special gas extractor PgS via switch S to valve R_3

Correction of the delivered liquid by the amount of entered gas

The MS might be equipped with bubble sensors. They are located at the inlet side of the pump for the registration of the bubbles to adjust the pump speed; at the outlet side of the meter for the quantification of the bubbles´ volume for correction of the metered volume. The correction device is usually embedded in the ECID.

Prevention of gas entering the pipework

Sensors like level detection sensors, pressure sensors, etc. are located at appropriate sites of the pipework for registration of the supply conditions and act on the risk of gas entry by switching off the pump or by closing a delivery valve.

Device which corrects the delivered liquid, when the MS runs empty

Prior to a delivery the outlet valve is closed while sensors automatically check the state of filling of the delivery pipe and if necessary, trigger its complete filling and the venting of air by opening appropriate venting devices.

When a sensor upstream of the meter registers the end of the liquid flow during a delivery, the quantity registration by the meter is finished and the residual liquid quantity is delivered via the open outlet pipe until a sensor signals the empty state.

The amount of residual liquid is measured at the first verification and is a fixed amount. This fixed amount will have to be added to the measured quantity when the sensor at the outlet signals empty state of the complete pipework.

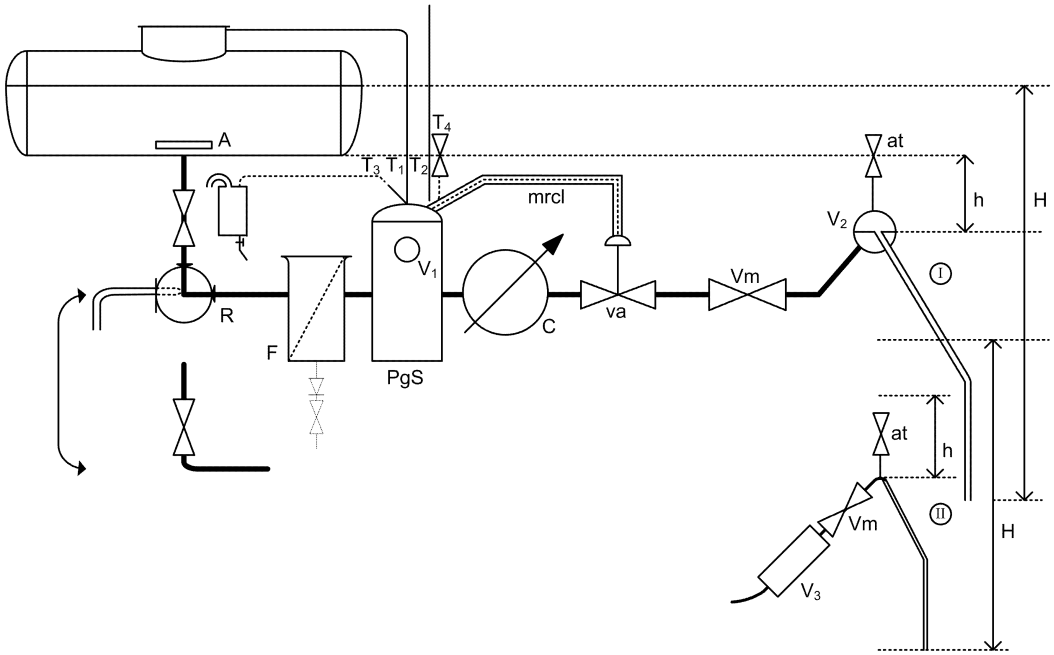
A.5 Device for the injection of additives

The amount of additive based on the amount of delivered product and on the prescribed additive mix ratio is automatically calculated and controlled by the ECID. Depending on the flow rate an additive injection unit is triggered to inject the correct amount of additive.

Standard scheme S1

Operation by gravity without permanent vent at point of transfer during delivery

Allows: (a) metered delivery (empty hose);
(b) direct unmetered delivery, emptying and filling of the tank without passing through the meter.



Key to standard scheme S1

The pipework between compartments and measuring systems must be such as to ensure permanent connections.

A:	Bottom valve.
R:	Two-way valve allowing metered delivery, unmetered delivery and emptying and filling of the tank without passing through the meter. This valve is optional. It may be replaced by a direct connection.
F:	Filter. A drain valve is authorized only if it includes a non-return valve preventing any admission of gas to the measuring system.
PgS:	Special gas extractor.
V_1:	Sight glass of special gas extractor.
T_1, T_2,T_3, T_4:	Variants authorized for the venting device. T_1: return to tank. T_2: vent to the atmosphere. T_3: vessel to catch liquid particles entrained by the gases. T_4: blow-off valve.
C :	Meter.
va:	Valve automatically closed by the special gas extractor when the pressure is insufficient to prevent vaporization in the meter or when a gas pocket accumulates in this special gas extractor. In addition, this valve must close in the event of a failure in its control system.
mrcl	Metrologically relevant communication line.
I and II:	Variants of the empty-hose delivery system. Variant I: weir-type sight glass V_2. Variant II: sight glass, also performing the function of a gas indicator V_3.
Vm:	Operating valve. The-automatic valve va and the operating valve Vm may be combined in a special valve performing both functions. In that case, the two functions must be independent of each other. In Variant II, this special valve must be placed after the sight glass V_3.
at:	Manual vent. It may be automatic (e.g., automatically closed during the measuring operation and opened on completion thereof).
H:	Head of liquid.
h:	Height of bottom of tank above point of transfer. This must be sufficient to ensure a flow rate at least equal to the meter's minimum flow rate until the tank is completely empty.

Standard scheme S2

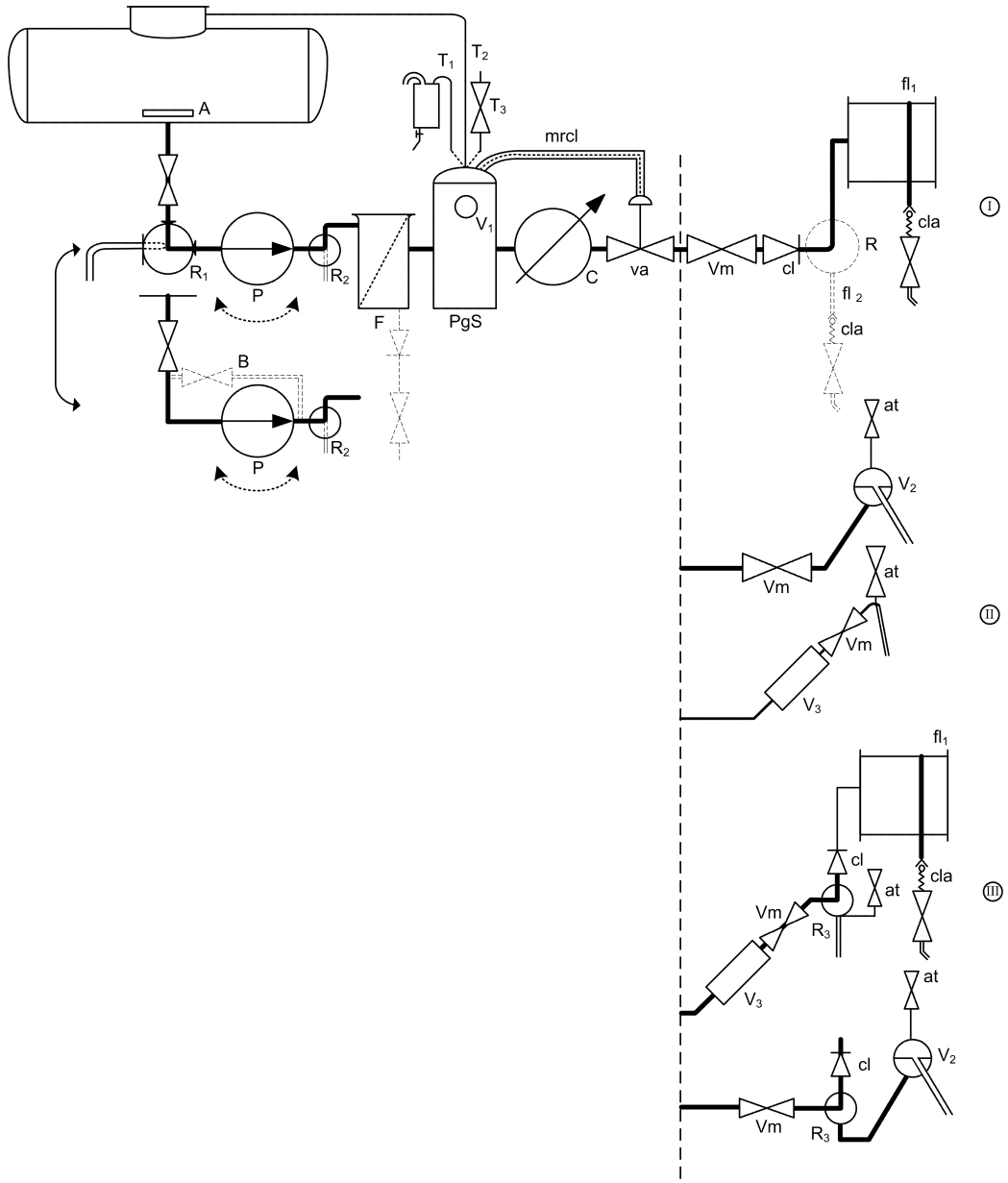
The measuring system includes a pump, a special gas extractor, one or two full hoses, or one empty hose or one full hose and one empty hose.

Allows:

(a) metered delivery by pump (full or empty hose);

(b) metered gravity-feed delivery (empty hose);

(c) direct delivery with or without pump, without passing through the meter, and emptying and filling of the tank without passing through the meter.



Key to standard scheme S2

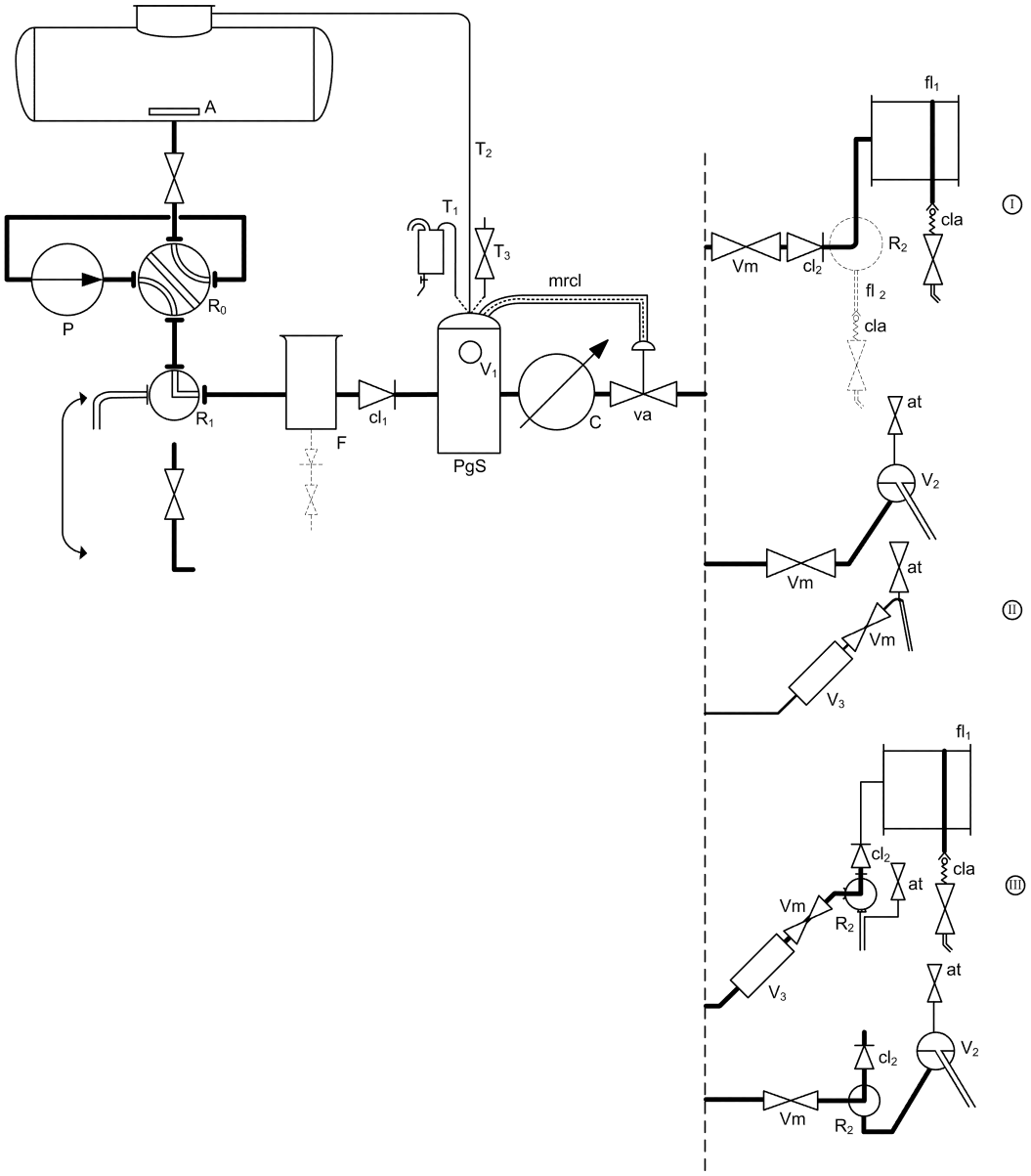
If the tank has several compartments and if it is possible to use a manifold, the valves in the bottom of the compartments and the valves on the intake pipe must be of the 'open or closed' type. Pipes between compartments and the measuring system must be permanently connected.

A:	Bottom valve.
R_1:	Two-way valve allowing metered delivery, unmetered delivery and emptying and filling of the tank without passing through the meter. This valve is optional. It may be replaced by a direct connection.
P:	Pump. The pump may be reversible. In that case, a non-return valve must be incorporated between the valve R; and the special gas extractor PgS.
B:	Optional bypass allowing metered gravity-feed delivery. (empty hose). This bypass is authorized only if there is no valve R_1.
R_2:	Optional two-way valve for direct unmetered delivery.
F:	Filter. A drain valve is authorized only if it includes a non-return valve preventing any admission of gas to the measuring system.
PgS:	Special gas extractor.
V_1:	Sight glass of special gas extractor.
T_1, T_2, T_3:	Variants authorized for the venting device. T_1: vessel to catch liquid particles entrained by the gases. T_2: return to the tank. T_3: blow-off valve.
C:	Meter.
va:	Valve automatically closed by the special gas extractor when the pressure is insufficient to prevent vaporization in the meter or when a gas pocket accumulates in the extractor. In addition, this valve must close in the event of a failure in its control system.
mrcl	Metrologically relevant communication line.
I, II, III:	Variants of the delivery device. Variant I: one or two full hoses; Variant II: empty hose; Variant III: combinations of one full and one empty hose.
Vm:	Operating valve. The automatic valve va and the operating valve Vm may be combined in a special valve performing both functions. In that case, the two functions must be independent of each other. This special valve must be placed downstream of the sight glass V_3 in those variants (II and III) which include the latter.
cl:	Non-return valve.
V_2:	Weir-type sight glass.
V_3:	Sight glass, also serving as a gas indicator.
fl_1:	Full hose on reel.
fl_2:	Optional second full hose (very short) for delivery at high flow rates.
cla:	Valve preventing the full hose from emptying
at:	Automatic or manual air vent.
R_3:	Device allowing deliveries to be made by either of two available delivery methods.

Standard scheme S3

The measuring system includes a pump, a three-way valve, a special gas extractor, one or two full hoses, or one empty hose or one full and one empty hose.

Allows: (a) metered delivery by pump (full or empty hose);
(b) gravity-feed metered delivery (empty hose);
(c) direct delivery with or without pump, without passing through the meter, and emptying and filling of the tank without passing through the meter.



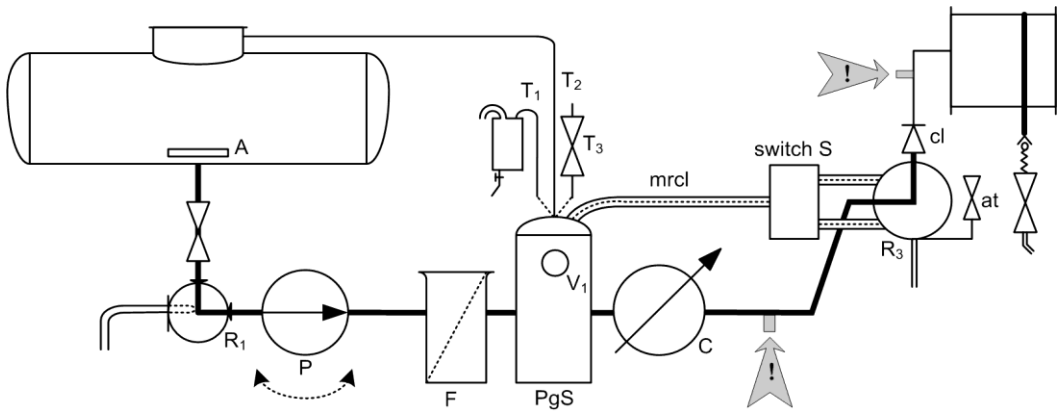
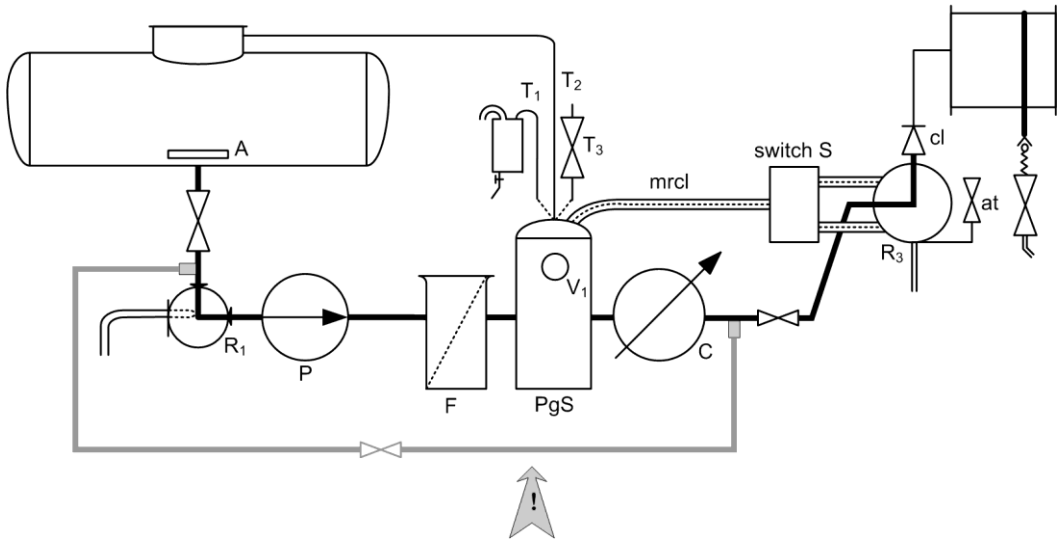
Key to standard scheme S3

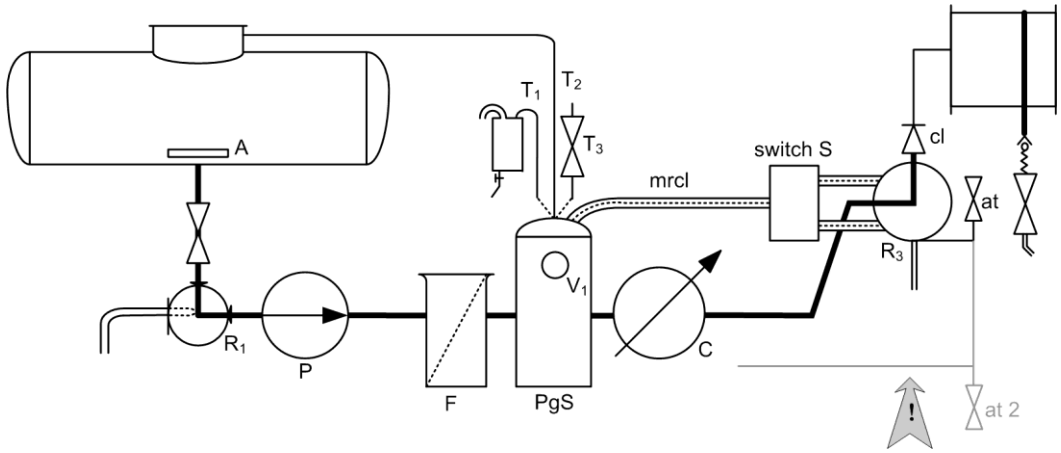
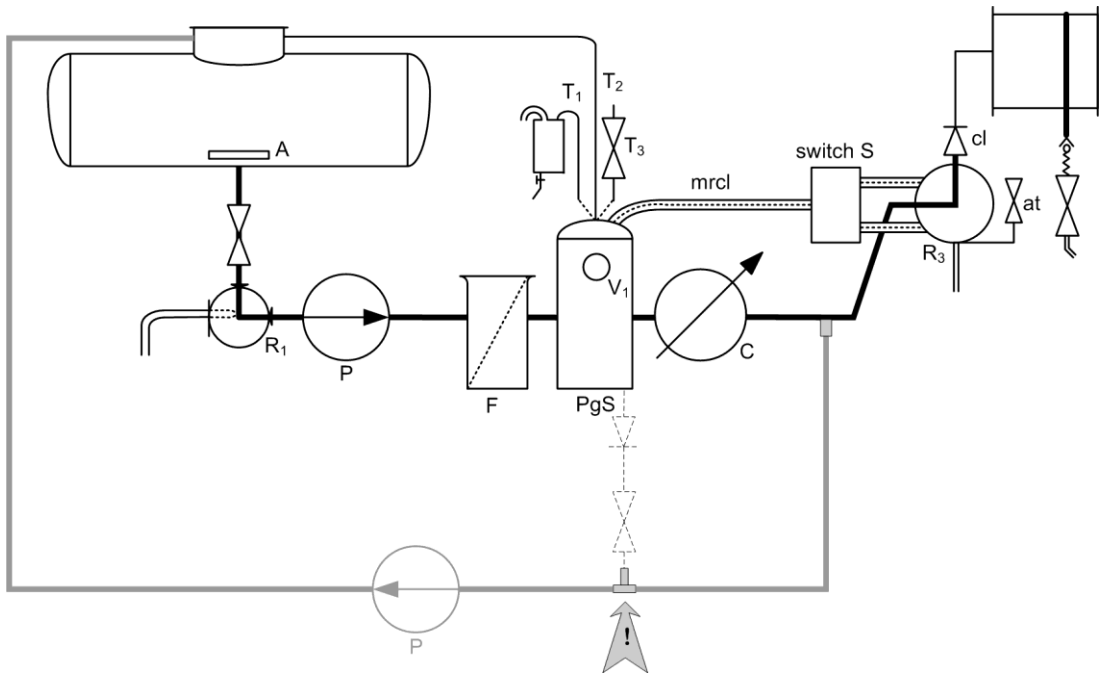
If the tank has several compartments and if it is possible to use a manifold, the valves in the bottom of the compartments and the valves on the intake pipe must be of the 'open or closed' type. Pipes between compartments and the measuring system must be permanently connected.

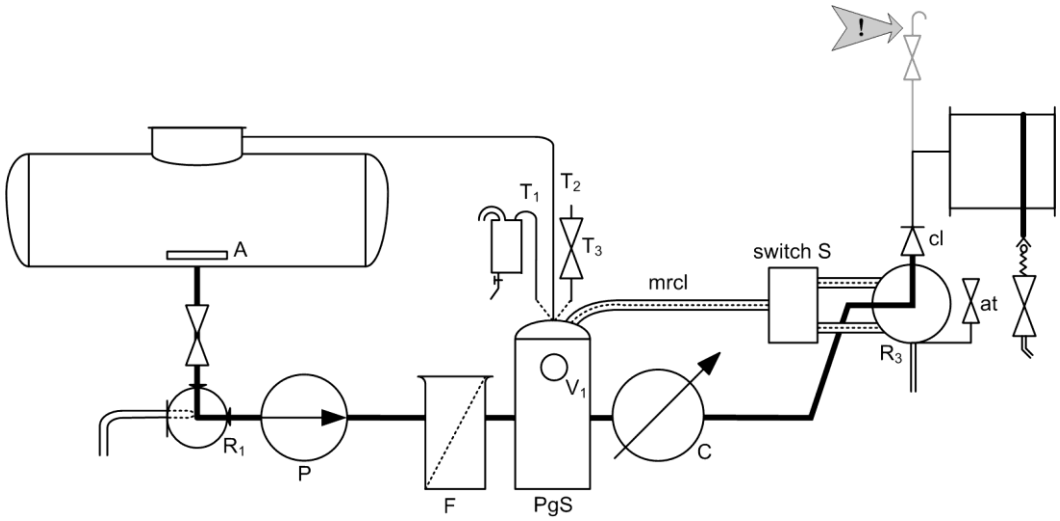
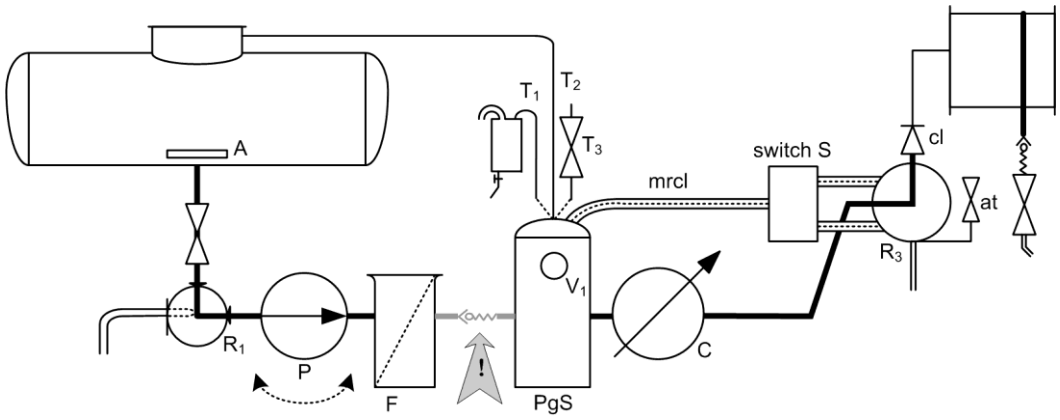
A:	Bottom valve
P:	Pump.
R_0:	Three-way valve which, in conjunction with valves R_1 and R_2, enables the following operations to be carried out: 1. Metered or unmetered delivery by pump (full or empty hose); 2. Gravity-feed metered or unmetered delivery (empty hose), emptying and filling of the tank; 3. Filling of the tank with the aid of pump P.
R_1:	This two-way valve is optional. It may be replaced by a direct connection.
F:	Filter: A drain valve is authorized only if it includes a non-return valve preventing any admission of gas to the measuring system.
cl_1:	Non-return valve.
PgS:	Special gas extractor.
V_1:	Sight glass for special gas extractor.
T_1, T_2, T_3:	Variants authorized for the venting device. T1: vessel to catch liquid particles entrained by the gases. T2: return to the tank. T3: blow-off valve.
C:	Meter.
va:	Valve automatically closed by the special gas extractor when the pressure is insufficient to prevent vaporization in the meter or when a gas pocket accumulates in the extractor. In addition, this valve must close in the event of a failure in its control system.
mrcl	Metrologically relevant communication line.
I, II, III:	Variants of the delivery device. Variant I: one or two full hoses. Variant II: empty hose. . Variant III: combinations of one full and one empty hose.
Vm:	Operating valve. The automatic valve va and the operating valve Vm may be combined in a special valve performing both functions. In that case, the two functions must be independent of each other. This special valve must be placed downstream of the sight glass V_3 in those variants (II and III) which include the latter.
cl_2:	Non-return valve.
V_2:	Weir-type sight glass.
V_3:	Sight glass also acting as a gas indicator.
fl_1:	Full hose on reel.
fl_2:	Optional second full hose (very short) for delivery at high flow rates.
cla:	Valve preventing the full hose from emptying.
at:	Automatic or manual venting.
R_2:	Device allowing deliveries to be made by either of two available delivery methods.

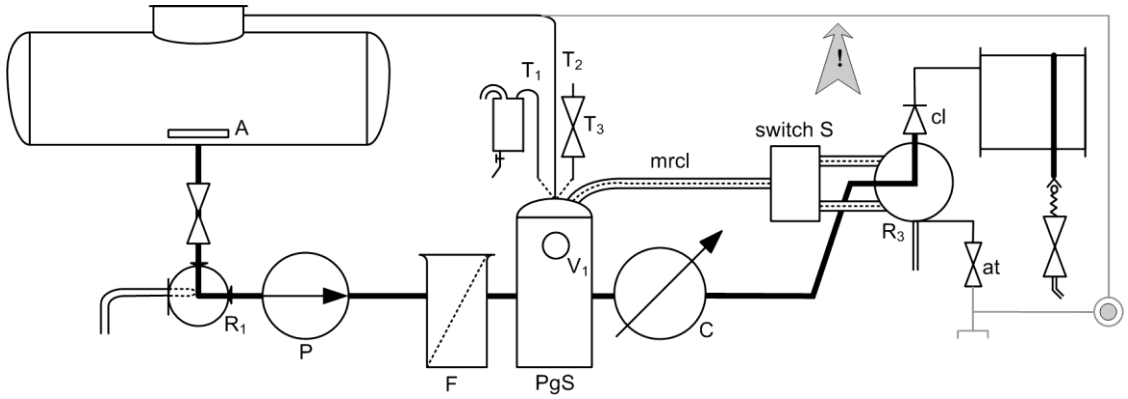
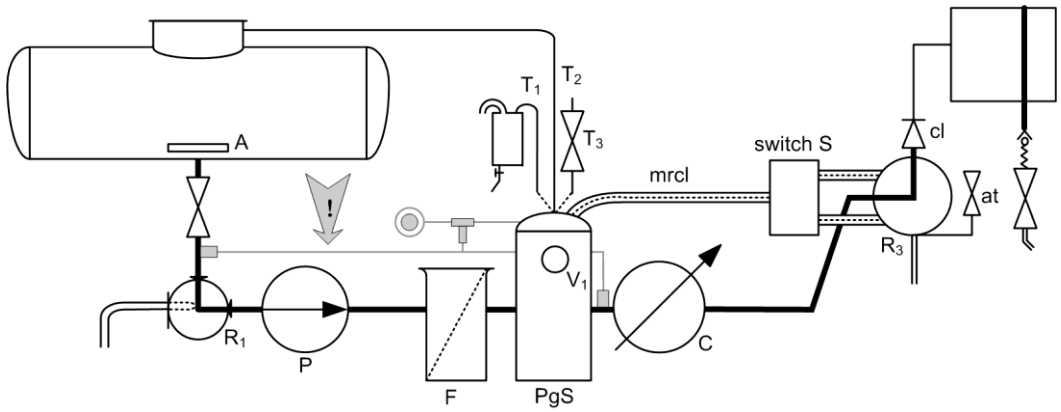
Annex B (informative) – Trouble Shooting table

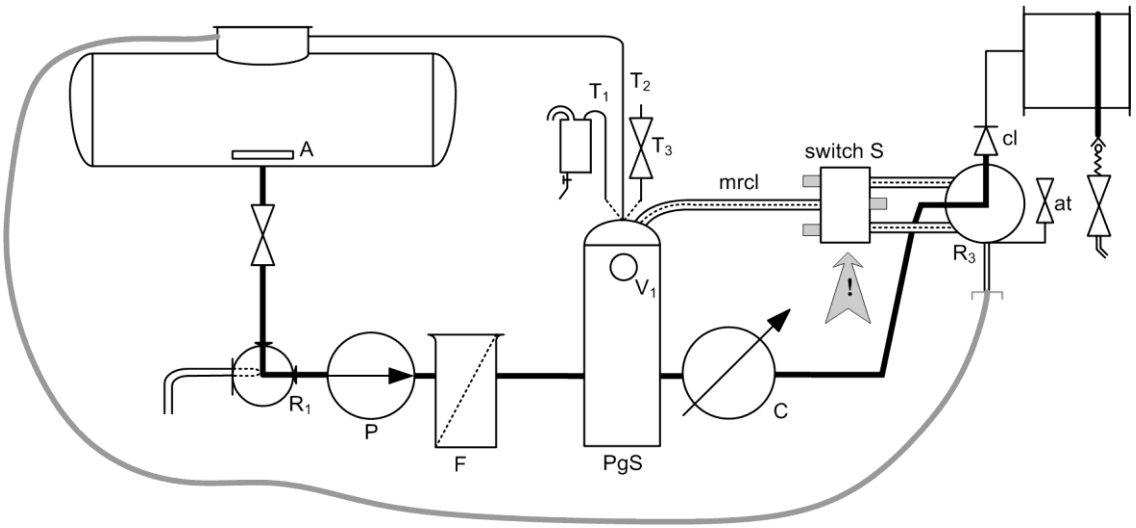
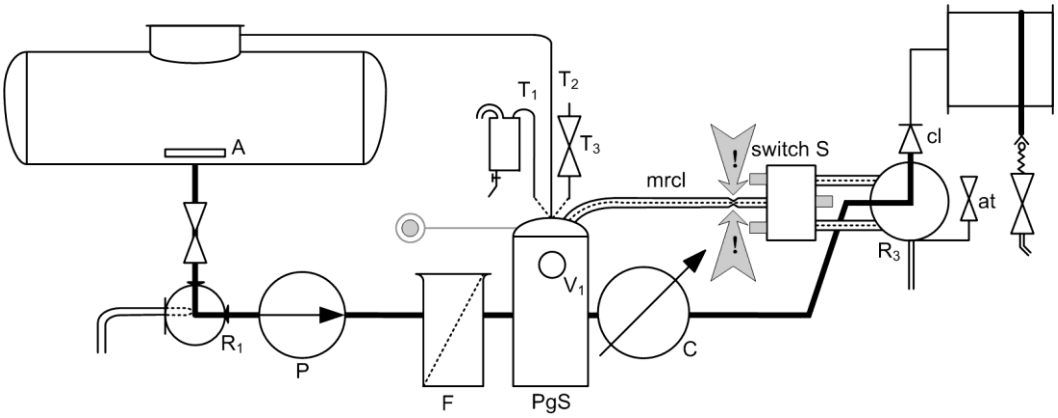
This informative annex shows examples of a fraudulent situation / arrangement and how to identify it and possible solutions of prevention / reducing the risk.

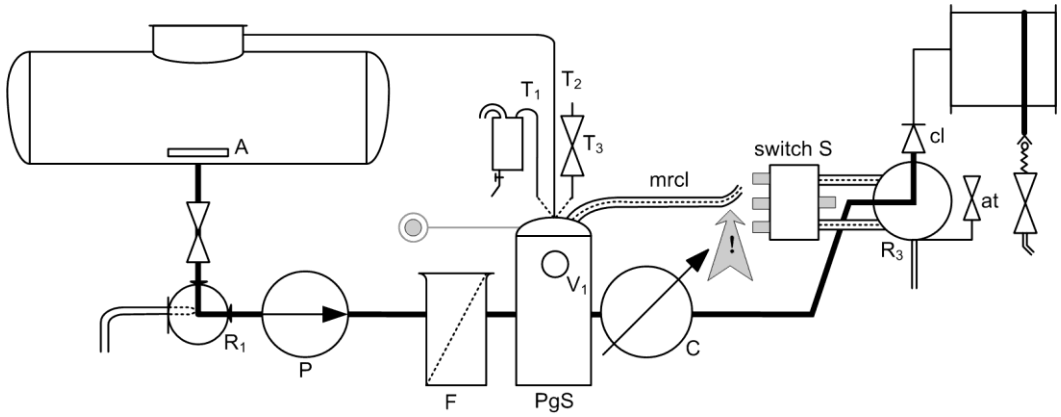
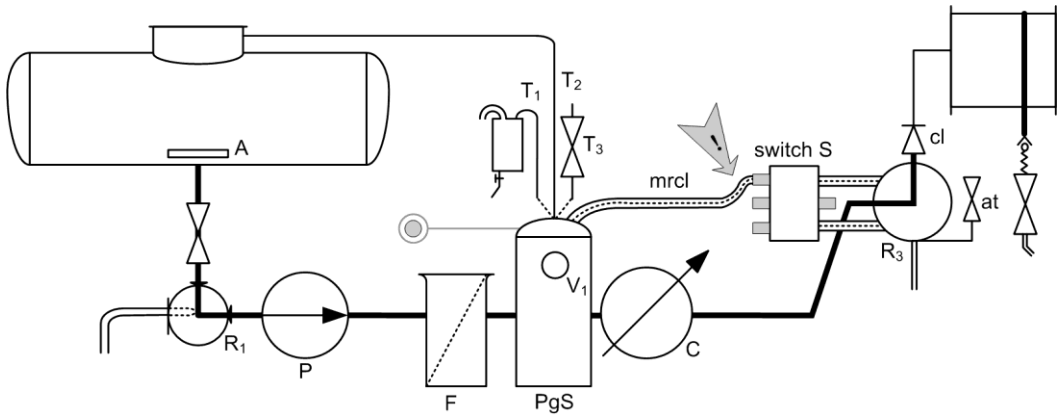
Example of a fraudulent situation / arrangement and how to identify it	**Possible solutions of prevention / reducing the risk**
 fig. B.1	
Adapters without any metrologically relevant function on the conduits of the liquid path downstream of the meter facilitate a connection of – temporary and permanent – pipes to divert any liquid, which has already been measured.	• Design precautions: Prohibit such adapters. • Test: Visual check; if such adapters are present, seal them against opening; seals shall be documented in the sealing diagram.
 fig. B.2	
Permanent conduits diverting from the liquid path downstream of the meter, potentially connected to the suction side of the pump or to the supply tank, facilitating to subtract any measured liquid from the customer during the delivery.	• Design precautions: No means shall be provided by which any measured liquid can be diverted downstream of the meter. • Test: Visually check for such diversions and for valves without any metrologically relevant functions in the liquid path. Note: Such diversions might be hidden (e.g. in the rear part of the cabinet) or masked (e.g. as a fake reinforcement or as

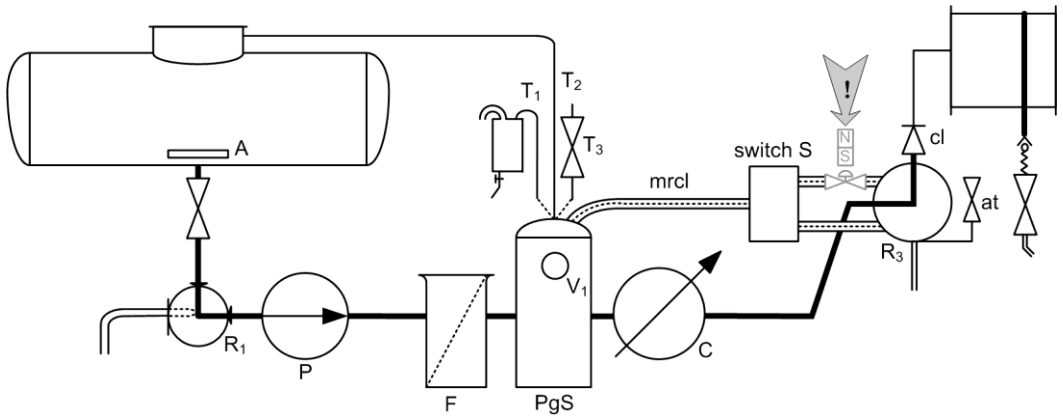
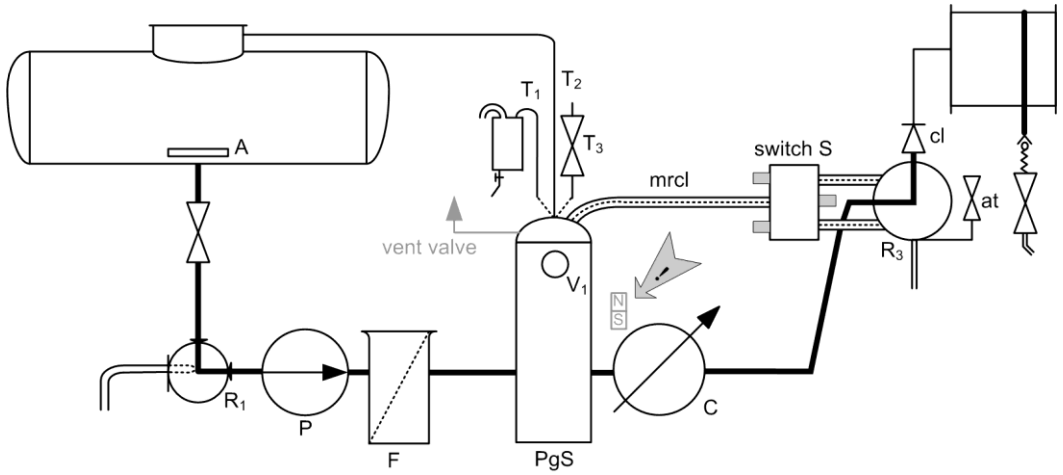
Example of a fraudulent situation / arrangement and how to identify it	Possible solutions of prevention / reducing the risk
	a fake housing); if present, remove them; if applicable, seal any adapters against opening; seals shall be documented in the sealing diagram.
 fig. B.3	
Additional authorized outlets passing to the opposite side of the road tanker: may be arranged on the opposite side in order to hide a diversion.	• Design precautions: Arrange conduits clearly visible, prevent conduits passing through the supply tank • Test: Visually check for such diversions and for valves without any metrologically relevant functions in the liquid path
 fig. B.4	
Authorized emptying device of the gas elimination device, but with unauthorized switch: enables diversion of liquid during a delivery	• Design precautions: Arrange conduits clearly • Test: Visually check for unauthorized switches; if present, seal them against opening; seals shall be documented in the sealing diagram.

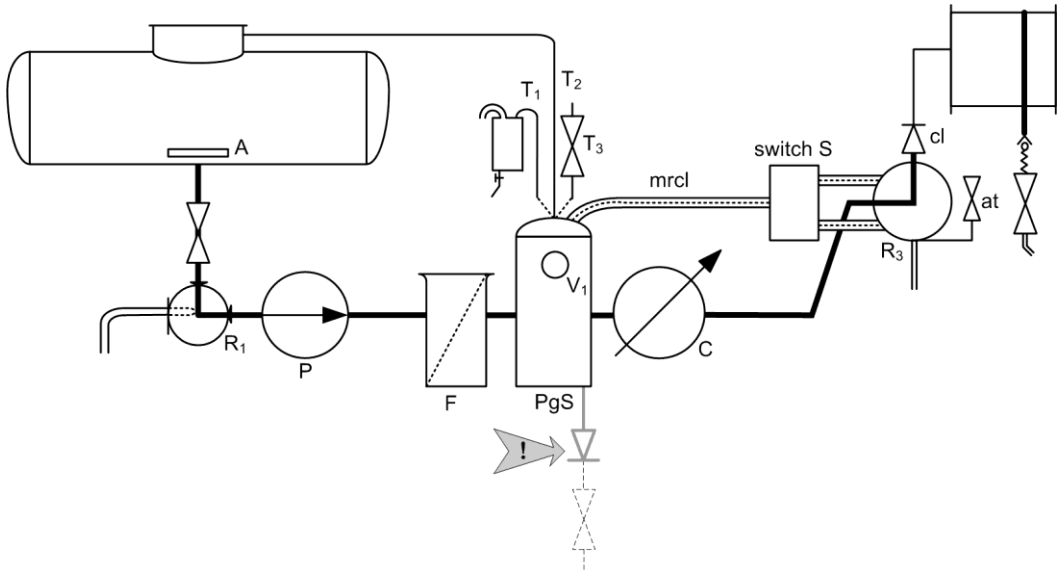
Example of a fraudulent situation / arrangement and how to identify it	**Possible solutions of prevention / reducing the risk**
 fig. B.5	
Adapter in the full hose facilitates to connect a diversion line, or a pressure line in order to blow out the full hose.	• Design precautions: No means shall be provided by which any measured liquid can be diverted downstream of the meter. No means for blowing out the full hose shall be provided. • Test: Visually check for any adapters in the full hose or pipework.
 fig. B.6	
Removing the non-return valve facilitates to drain the meter using a bidirectional pump.	• Design precautions: All metrologically relevant parts shall be secured against removal / disassembly; seals shall be documented in the sealing diagram. • Test: functional test by activating the reverse direction of the pump; the liquid level in the gas elimination device shall not be influenced; no activation of the gas elimination device.

Example of a fraudulent situation / arrangement and how to identify it	**Possible solutions of prevention / reducing the risk**
 fig. B.7	
Empty hose with authorized blowout device might facilitate the diversion of any liquid during a full hose delivery, if valve R3 has got a leakage to the empty hose adapter – intentionally or unintentionally.	• Design precautions: Arrange all conduits clearly visible. • Test: Visual check and leakage check of valves
 fig. B.8	
A connection of a pneumatic hose to the liquid pipework upstream of the meter facilitates the injection of small quantities of air into the liquid flow. The gas elimination device might not be capable of eliminating such small quantities of air out of the liquid. Such pneumatic lines might be masked as additive lines.	• Design precautions: Avoid unnecessary adapters on the liquid pipework; arrange communication line clearly visible; avoid unnecessary switches and valves in the communication lines • Test: Visually check for any suspicious adapters. If present: perform a functional check with respect to what happens in case of disconnecting the lines or opening the valve(s); perform two measurements: one with valves closed, one with valves open, with respect to a variation of errors

Example of a fraudulent situation / arrangement and how to identify it	**Possible solutions of prevention / reducing the risk**
 fig. B.9	
The setting of the switch for the selection of the delivery hose might be changed during a delivery. This facilitates the diversion of measured liquid back to the supply tank using a non-operated delivery hose.	• Design precautions: The switch for hose selection shall not permit the operation of two or more delivery hoses simultaneously. A change of the delivery hose during a delivery shall not be possible. • Test: Functional check, if the selection of the delivery hose is interlocked during a delivery, and if any change of the delivery hose is only possible after the indication has been reset to ZERO
 fig. B.10	
Buckling of a mrcl facilitates to get air pressure trapped inside the mrcl, by which the delivery valve can be hold in open position any time, even if the gas elimination device runs empty.	• Design precautions: Shield metrologically relevant communication lines against buckling or use a material that makes buckling traceable. Arrange metrologically relevant communication lines clearly visible. • Test: Visually check for buckled communication line. Look for grippers on the road tanker. Perform a measurement

Example of a fraudulent situation / arrangement and how to identify it	Possible solutions of prevention / reducing the risk
	with the compartment getting empty. Check, if a variation of error occurs.
 fig. B.11	
Disconnecting a mrcl facilitates any input of inadmissible signals to the switch (e.g. by connecting the switch to the air pressure supply). The outlet valve can be opened permanently, even if air/gas enters the gas elimination device and the meter. In this case it is possible to measure air instead of liquid.	• Design precautions: Secure connections of metrologically relevant communication lines. Avoid an unnecessary excess length of a metrologically relevant communication line. Pneumatic diagram shall be permanently available on the road tanker. • Test: Visually check, if the pneumatic control of the MS is in conformity with the documentation
 fig. B.12	
Interchanged/wrong connections of metrologically relevant communication lines facilitates an unauthorized use of the control system resp. of the measuring system.	• Design precautions: Secure connections of metrologically relevant communication lines. Avoid an unnecessary excess length of a metrologically relevant communication line. Pneumatic diagram shall be permanently available on the road tanker. • Test: Visually check, if the pneumatic control of the MS is in conformity with the documentation

Example of a fraudulent situation / arrangement and how to identify it	**Possible solutions of prevention / reducing the risk**
 fig. B.13	
Activating of an electrically operated solenoid valve using a strong magnet	• Design precautions: Secure solenoid valves by locating them in a not accessible box, by shielding, or by using self-monitoring solenoid valves. • Test: Visually check for any magnets on the road tanker.
 fig. B.14	
Blocking the vent valve of the gas elimination device facilitates the entrance of gas into the meter; blocking of the venting line connected to the supply tank; blocking the operation of the gas elimination device by a strong magnet	• Design precautions: Design vent valves against closure; protect gas elimination devices from the being influenced by strong magnets; arrange mrcl clearly visible so that blocking / buckling can be discovered. • Test: Visually check for any magnets on the road tanker.

Example of a fraudulent situation / arrangement and how to identify it	Possible solutions of prevention / reducing the risk
 fig. B.15	
Removal of non-return valve of the drainage pipe facilitates the suction of air during an empty hose delivery or the injection of air.	• Design precautions: Secure metrologically relevant parts against removal • Test: Visually check if the non-return valve is correctly built in and sealed; functional check of the non-return valve

Example of a fraudulent situation / arrangement and how to identify it	Possible solutions of prevention / reducing the risk
The parameters used for a conversion are not in line with the actual measured product. There are inadmissibly changed parameters e.g. nature of products, product density, conversion formula, invariables, temperature measurement, etc.	• Design precautions: All the metrologically relevant parameters shall be secured, potentially by a non-resettable event logger, which saves any changes to a history file or to a non-resettable event counter. A verified print-out of the legally relevant parameters shall be available in the documentation. • Test: Visually check, if the calculator's seal is undamaged. Check, if the metrologically relevant parameters have been changed since the last verification. Check, if the event counter has not changed.
Actual temperature is not measured/not measured correctly	• Design precautions: Temperature sensor shall be sufficient length (maybe placed into pipe in sidelong position or axial due the elbow) and sufficient heat transfer during its coating; cable connection are to be secured • Test: Visually check the installation; check the cable connections and securing means; check for additionally unauthorized components in the electric circuit, with a special focus on additional resistors