

PURGE & PRESSURISED SYSTEM – ATEX CABINET

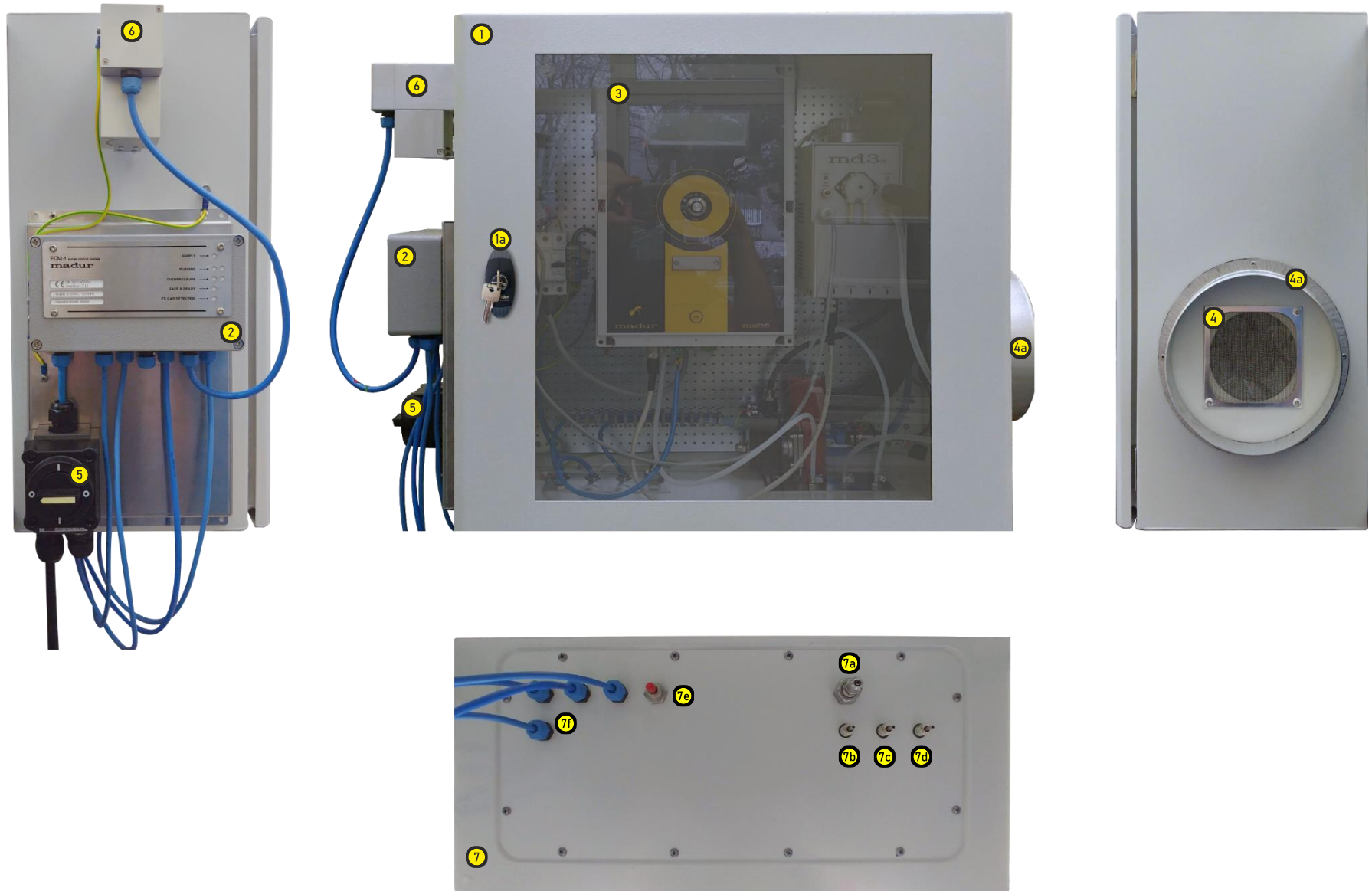
User guide

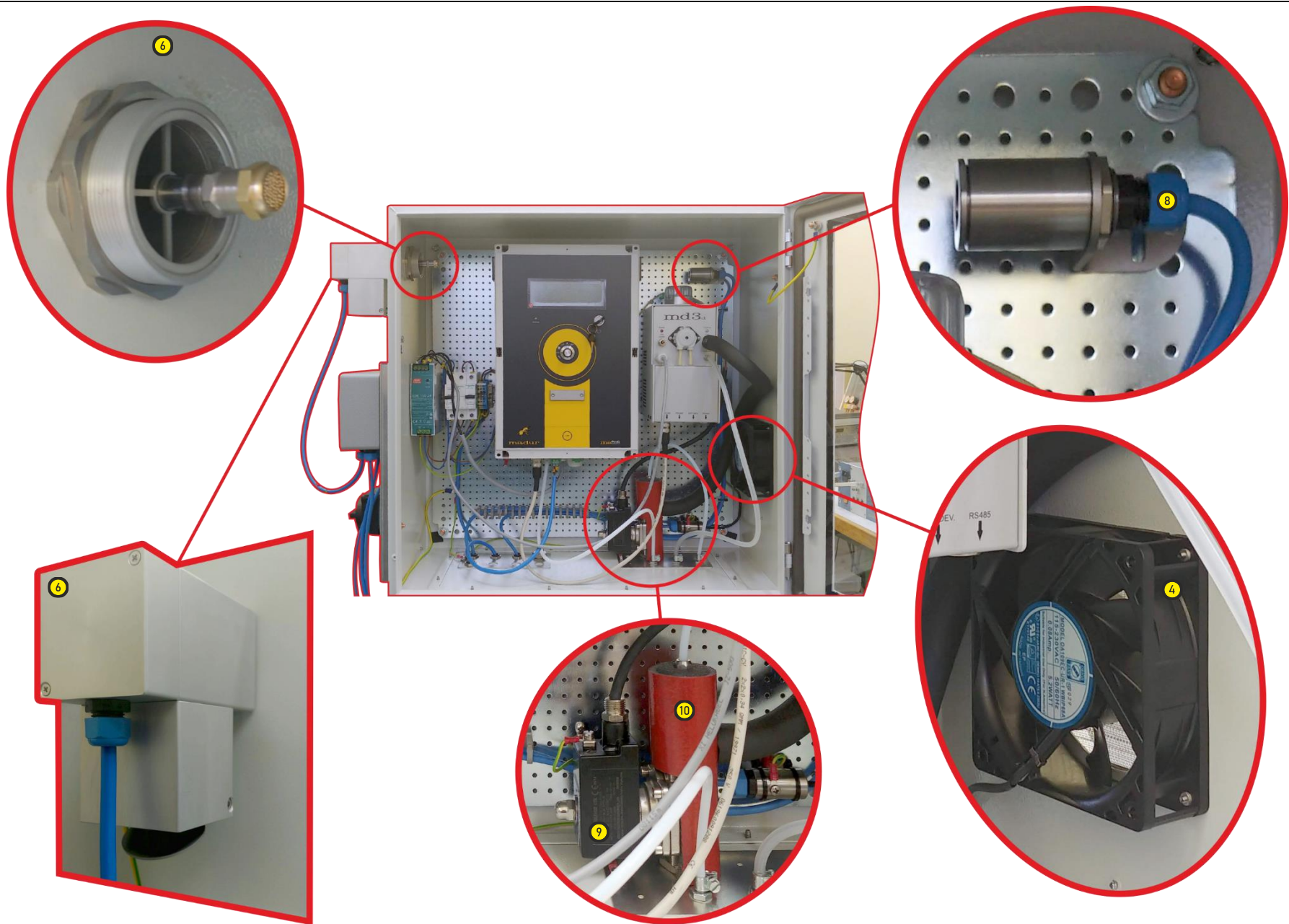
Version: 1.0
12/2021


madur
E L E C T R O N I C S

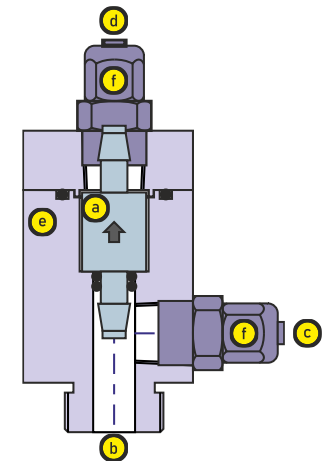
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1. CONSTRUCTION





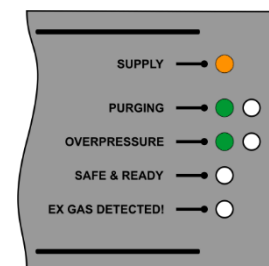
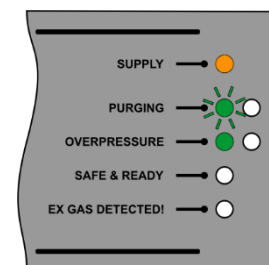
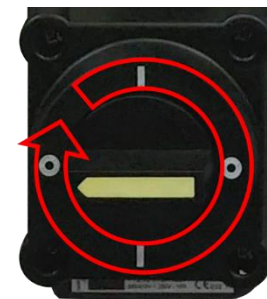


1. IP55 cabinet where gas analyser and equipment are installed
 - a. According to ATEX norm 60079-2, all doors and covers cannot be opened without a use of a tool. We have decided to protect the door with a key-locked mechanism.
2. Purge and Purging control module – designed to be intrinsically safe (in conformity with norm 60079-11 – ATEX certification pending). P&P module, based on the assisting sensors (flow, pressure and LEL) decides on when it is safe to energise the protected equipment, or in case of emergency when to remove power in order to prevent a potential source of spark and explosion.
3. Gas analyser, dryer and other non-ATEX rated equipment that require protection by P&P system.
4. Purging fan (ATEX certified). Non-ATEX devices inside the cabinet are allowed to operate (to be energised) only when the atmosphere inside the cabinet does not contain hazardous (explosive) gas. Fan drives ambient air from outside hazardous zone and, in consequence, removes any potential leakages of explosive gas inside the cabinet.
 - a. In case when cabinet is installed in hazardous zone, ambient air outside is also considered as hazardous, and as such cannot be used for purging purpose. Therefore, fresh air for cabinet's ventilation must be ducted from the outside of the hazardous zone. Cabinet can be equipped with 199mm diameter flange that allows to connect air duct.
5. ATEX rated main switch. Optionally may supply other equipment e.g. heated line 4.
6. Ventilation outlet with pressure and flow sensor. To recognise the atmosphere inside the cabinet as safe, cabinet must be continuously flushed with ambient air (or other neutral gas, e.g. nitrogen). Pressure sensor checks if the overpressure inside the cabinet is as required +50Pa. It also checks if the flow at the vent outlet is not obstructed to maintain proper purging of the cabinet.
7. Bottom panel of the IP cabinet gathers all gas and electrical connections. Because this part varies depending on the cabinet's configuration, please refer to the topology map, provided with the individual cabinet.
8. LEL sensor – redundant protection (not required by 60079-2). This ATEX certified sensor detects leakages of explosive gas inside the cabinet, and deenergises protected equipment if gas concentration exceeds $\frac{1}{2}$ of the lower explosive limit.
9. Shut-off (normally closed) solenoid valve – another redundant protection (not required by 60079-2). In situations when device is not power on, or when P&P module deenergises protected equipment inside cabinet, this valve is also deenergised (=closed) and blocks access of the measured gas to the analyser, preventing it to build up inside the analyser or cabinet.
10. Check valve with cracking pressure 1 PSI (~70mbar) – protects the analyser against unexpected pressure build of the process gas:
 - a. Check valve
 - b. Gas source – directly connected to the shut-off valve 
 - c. Gas outlet – to the analyser (when process pressure <1PSI)
 - d. Excess gas outlet – when process pressure exceeds 1PSI, check valve opens and gas excess is released to waste
 - e. Valve corpus
 - f. Compression fittings



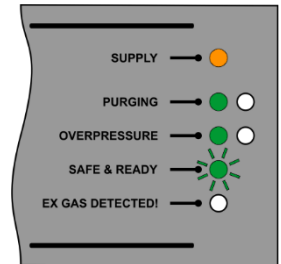
2. LAUNCH PROCEDURE

1. Before launching the measurement system, make sure that the cabinet is closed and secured . Key should be removed to avoid unauthorised modifications of the analyser and/or its equipment
2. Put the main switch  to ON (#1) position.
P&P module energises ATEX-rated peripherals, i.e. fan, LEL sensor, flow & pressure sensor.
3. *Start-up phase* begins - fan starts purging the cabinet. This phase ends when target pressure (+50hPa) inside the cabinet is reached (but not sooner than phase min. time = 20 sec). Afterwards, P&P module goes to *Cleaning phase*.
In case target pressure cannot be reached (e.g. because cabinet is not closed properly) and *Start-up phase* max time (=240sec) is reached, system goes to *Error phase*.
4. *Cleaning phase* - fan continues to purge the cabinet. Flow&pressure sensor controls cabinet's overpressure, LEL sensor monitors concentration of explosive gases. *Cleaning phase* ends when:
 - a. Minimum cleaning time has been reached – see chapter 2.2.
 - b. Explosive gas concentration is below $\frac{1}{4}$ of LEL.
If LEL sensor detects combustible gases $> \frac{1}{4}$ LEL after MinCleaningTime has been reached, P&P module continues purging until combustibles concentration drops below $\frac{1}{4}$ or MaxCleaningTime is reached (by default set to 10 min) – in such case P&P module goes to *Error Phase*.
 - c. Pressure inside the cabinet during entire *Cleaning phase* has not dropped below the target one for longer than 10 seconds. If this condition is not met, P&P module goes to *Error Phase*
5. After *Cleaning phase*, module goes to:
 - a. In case of a single-module system → *ReadyAndOn phase*
 - b. In case of a multi-module system (cabinets working in network in Master-Slave relationship) → *ReadyWaiting4Others phase*



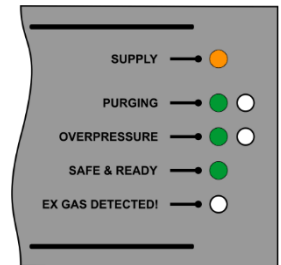
6. *ReadyWaiting4Others* – given P&P module reports its readiness to the other modules via control line. Only when all connected modules reports they are ready to work, entire system goes to *ReadyAndOn* phase.

(Single-module system has phase *ReadyWaiting4Others* fixed for 10 seconds)



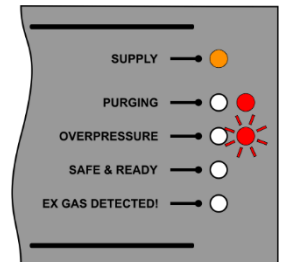
7. *ReadyAndOn* – this is when environment inside the cabinet(s) is considered as safe, and when protected devices are energised. System remains in this phase as long as all of the following conditions are met:

- In case of multi-module system - Control line is clear (=all modules are in *ReadyAndOn* phase) – failing this condition shifts system to *ReadyWaiting4Others* phase, and can return to *ReadyAndOn* when all modules report readiness.
- Pressure inside the cabinet has not dropped below the target one for longer than 10 seconds – failing this condition shifts system to *Error* phase
- Concentration of combustible gases is below $< \frac{1}{2}$ LEL – failing this condition shifts system to *Error* phase

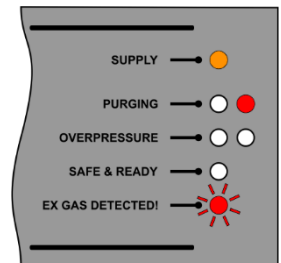


8. *Error* phase – Protected equipment as well as ATEX rated devices (fan, pressure sensor, LEL sensor) are deenergised. P&P module “latches” information about the cause of the error – here pressure sensor triggered error phase.

It is not possible to restart from this phase automatically. The only method is to restart entire system by manually resetting mains switch ⁵ to #0 and back to #1, when entire launch sequence restarts from the beginning.



9. *Error* phase triggered by LEL sensor – it has detected concentration of combustible gases above $\frac{1}{2}$ of LEL



2.1. Temporary errors

Both pressure & flow and LEL sensor may register positive signal, but does not (immediately) trigger an error:

- Minor fluctuations of pressure signal are acceptable. E.g. temporary flow distortion* at cabinet's outlet does not terminate the cleaning procedure. Only when the pressure & flow sensor reports "deficiency" for longer than 10 seconds then system goes to error phase.

Same 10-seconds rule applies when system is in the ReadyAndWaiting4Ohters or ReadyAndOn phases.

*Outlet flow could be distorted e.g. by wind blows directly at the cabinet



- LEL sensor may detect presence of combustible gas at the beginning of cleaning phase – that is perfectly normal, as purpose of this phase purpose is to flush out any remains of hazardous gases from cabinet. Because flushing with ambient air (neutral gas) is performed continuously, methane bleeds to the cabinet's inside are not dangerous (because it is supposed to be purged outside). System continuous working until LEL sensor detects presence of combustible gases above ½ LEL. Any value beyond that triggers system's error.



2.2. Minimal purge time

Norm 60079-2, paragraph 7.8 specifies purging time to be long enough to exchange air volume equal to five enclosure volumes. This time is calculated based on cabinet size:

- 60x60x30cm – volume is 108 litres
- 80x60x30cm – volume is 144 litres

and selected fan's efficiency- according to manufacturer's specification it is 990 litres/min @ 50Pa load.

144 litres x 5 = 720 litres → 720 litres / 990 litres/min = 44 seconds.

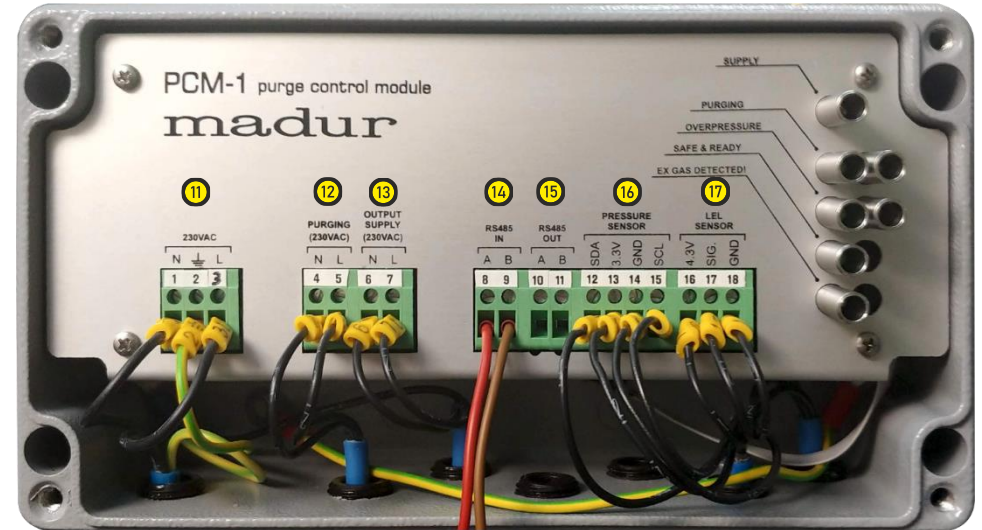
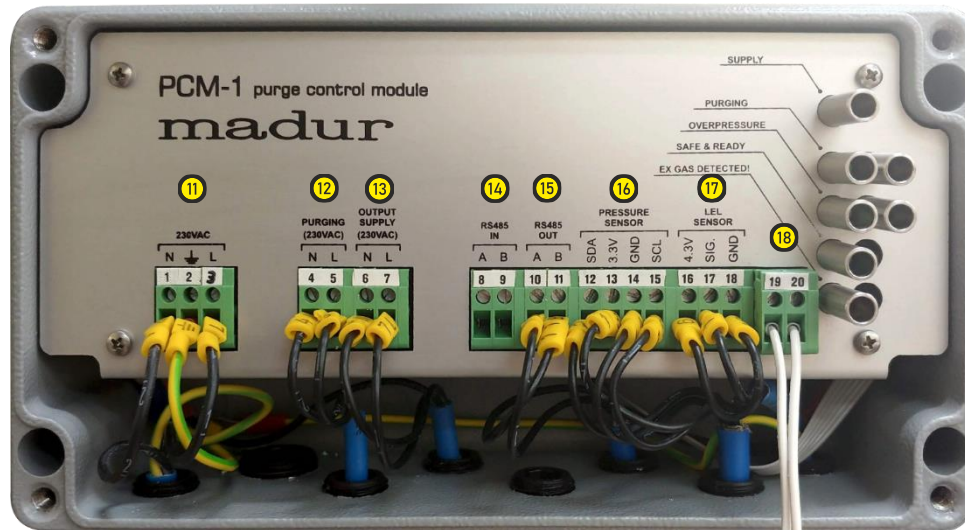
Despite the norm requirements, madur considers the worst case scenario to determine minimum time required for initial purging. The worst case scenario, i.e. cabinet is fully filled with explosive gas = 100%vol methane. It is necessary to inject air in volume about 20x volume of cabinet to the dilute air inside the cabinet to the safe level (Safe level is below LEL, for methane it is 4,4%vol.) Because air in the cabinet is purged and not diluted, in fact it is necessary to inject less protective gas, nonetheless we will use 20x cabinet's volume for further calculations:

144 litres x 20 = 2880 litres → 2880 litres / 990 litres/min = 2,91 min (175 seconds). Considering potential drops of fan's efficiency, madur sets the purge time to 240 seconds (4 minutes).

3. P&P MODULE – ELECTRIC CONNECTIONS

MASTER

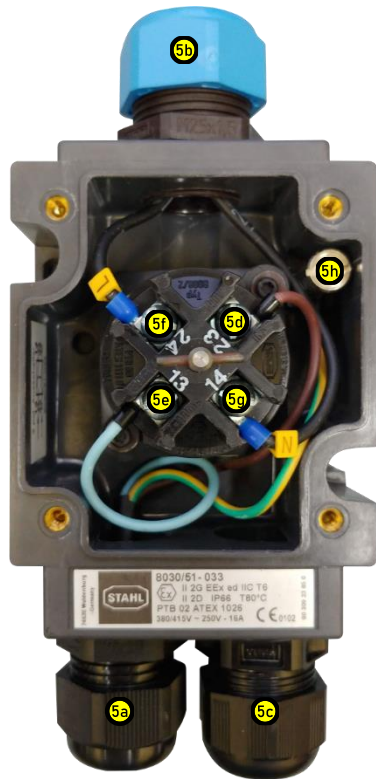
SLAVE



P&P module is designed intrinsically safe, i.e. in compliance with norm 60079-11. It is IP55 rated, and is equipped with special, ATEX-rated cable passes.

11. Mains supply connected via ATEX-rated switch (5)
12. Terminal for cabinet's purging fan (4)
13. Terminal for protected equipment (3)
14. MASTER module – RS485 terminal to connect external devices with the protected analyser inside
SLAVE module – control line for master-slave relationship. Slave reports to Master it is purged and ready to work. When all modules are in *ReadyWaiting4Others* phase, Master module decides to go to *ReadyWaiting4Others* phase when protected devices are energised.
15. MASTER module – RS485 line to the analyser
SLAVE mode – not in use
16. Flow and pressure sensor terminal (6)
17. LEL sensor terminal (8)
18. This terminal is available only for MASTER module – Control line for master-slave relationship. Multi-module system works in star topology with master being in the centre. All Slave modules are connected with master using this terminal (16)

4. MAINS SWITCH



Mains switch **5** – ATEX rated cam switch. Allows to safely connect P&P module and external devices like third-party heated line:

- a. Cable pass for the mains supply cable
- b. Cable pass to supply P&P module
- c. Cable pass to supply external devices e.g. ATEX rated heated line
- d. Line inlet terminal
- e. Neutral inlet terminal
- f. Line outlet terminal
- g. Neutral outlet terminal
- h. GND

