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AMSTERDAM - THE NETHERLANDS

SHELL EO/EG PROCESS MEMORANDUM 112

SUBJECT : CO₂ REMOVAL SHUT-DOWN SYSTEM
DATE OF ISSUE : SEPTEMBER 2005

This document describes the minimum specifications for the safeguarding system for the carbon dioxide removal unit. The main purpose of the system is to prevent carry-over of carbonate solution to the EO catalyst bed, which would permanently deactivate the catalyst.

The protection level by the various safeguarding systems is based on a classification of the risks in the CO₂ removal section in terms of safety, environment, equipment loss and production loss as well as the probability of occurrence. The system is fit for purpose in terms of risk protection, cost and operability. In order to assure adequate safeguarding the trip initiators and actuators need to be field tested regularly. This test frequency should be determined by the detailed engineering contractor.

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1 INTRODUCTION

The CO₂ removal shut-down system will shut-off the loop gas and the lean carbonate to the CO₂ absorber when carry-over is imminent or has begun. At the same time the CO₂ absorber gas breakthrough system prevents breakthrough of loop gas to low pressure equipment and from there to atmosphere.

Carbonate solutions have a tendency to foam, particularly during the initial start-up period when manufacturing oil and particles such as rust may be prevalent. Foaming at high gas rates or in case of rapid increases in gas rates have resulted in sudden carry-over of carbonate solution from the CO₂ absorber.

A knock out drum is provided to prevent carbonate carry-over from reaching the EO catalyst bed. During normal operation, the water knock out drum separates entrained condensate from the CO₂ absorber overhead gas.

2 AUTOMATIC SHUT DOWN SYSTEMS

Refer to figures 1 for the CO₂ removal unit sketch and 2 and 3 for details of the safeguarding logic diagrams.

Alarms are required as early warning prior to a trip initiator being reached. Trip initiators should be separate from process controllers. The instrumentation shall fail to a safe mode in case of loss of any utility.

Shut-down system valves must be TSO valves. All valves that are part of the shut-down system shall be fitted with proximity switches to indicate open and closed position. Position mismatch alarms are required.

There are no maintenance override switches shown on the logic. Maintenance override switches may be required, although they should be minimised as much as possible. In case maintenance override switches cannot be omitted,



access to these switches should be controlled and the use should be regulated. For requirements on the use and application of maintenance override switches see DEP 32.80.10.10, Chapter 4.5.9.

A graphics view on the DCS will show positions of all relevant valves and process variables for ease of overview by the operator.

The automatic shut-down system for the CO₂ removal unit provides appropriate safety actions for the various possible abnormal operating conditions. In that respect the following emergency systems can be distinguished:

1. CO₂ removal shut down system
2. CO₂ absorber gas breakthrough system
3. Water KO drum gas breakthrough system
4. Water KO drum emergency discharge system

2.1 CO₂ removal shut down system

Various abnormal operating conditions related to the CO₂ removal will isolate this unit and bring it to a safe mode.

A CO₂ removal shut down will be initiated in case of:

1. Very high level in the water KO drum (LZA-202-HHH).
2. High level in the CO₂ absorber (LZA-209-HH).
3. High loading in the CO₂ absorber as indicated by high differential pressure (PDIZA-211-HH) between the top and bottom of the column.
4. Low gas feed flow to the CO₂ absorber as indicated by low differential pressure (PDZA-206-LL) in the gas feed line across the feed valve UZV-203.
5. Inadequate lean carbonate feed to the CO₂ absorber as indicated by low differential pressure (PDZA-215-LL) across the lean carbonate flow control valve (FCV-214) as well as the low flow indicator on the lean carbonate flow (FIZA-213-LL).
6. Low flow of lean absorbent to the EO absorber (FIZA-251-LL).



7. Emergency stop (HZ-230).

On activation of the CO₂ removal shut down system, the following actions will take place:

1. CO₂ absorber gas feed shut-down valve (UZV-203) closes.
2. CO₂ absorber gas bypass control valve (PCV-205) opens fully.
3. The block valve (UZV-205) and the control valve (FCV-214) in the CO₂ absorber lean carbonate feed close. Since the carbonate pump keeps running it is required to automatically open the minimum flow return line to protect the pump.
4. CO₂ stripper reboiler steam control valve (FCV-216) closes slowly via the DCS, while solenoid valves enforce the closing of the valves after about 20 seconds.
5. Anti-foam dosing valve to suction of the carbonate pump closes to stop anti-foam injection into the lean carbonate.
6. FCV-215 in carbonate filter line closes.
7. Lean carbonate recycle valve (FCV-222) opens fully.

In case of shut-down of the gas feed to the CO₂ removal unit only, that is in case of too low lean absorbent flow to the EO absorber or too low differential pressure over the gas feed line to the CO₂ absorber, the carbonate circulation will continue. In case of shut-down of the gas feed the heat input to the CO₂ stripper reboiler will stop to prevent over-concentration of the carbonate solution due to the fact that less heat input is required when the gas feed to the unit is shut down.

2.2 CO₂ absorber gas breakthrough system

In case of low level in the CO₂ absorber, the fat carbonate flow from the CO₂ absorber bottoms has to be cut off to prevent breakthrough of loop gas to low pressure equipment and from there to atmosphere.

Low level in the CO₂ absorber (LZA-207-LL) must close the block valve (UZV-204) and control valve (LCV-210) in the fat carbonate line from the CO₂



absorber bottom. The operation of the shut-down valve can be tested while in operation. These valves will only close in case of low liquid level of the CO₂ absorber. There is no direct action through the CO₂ removal shut-down system to prevent building up of fat carbonate in the bottom after a trip. Normal level control will continue to function, closing the control valve as necessary.

In the carbonate solution, crystals can be formed that can block the control valves in the CO₂ absorber bottom line. Therefore a valve closing test using a position indicator (GBZ-204) is installed on the blockvalve UZV-204 (refer to figure 3).

2.3 Water KO drum gas breakthrough system

In case of low level in the water KO drum the bottom flow has to be cut off to prevent breakthrough of loop gas to low pressure equipment and from there to atmosphere.

Low level in the water KO drum (LZA-201-LL) must close outlet valve UZV-202.

2.4 Water KO drum emergency discharge system

To prevent carry-over from the water KO drum, a safeguarding system is provided. Both LZA-204-HH as well as LZA-202-HHH in the water KO drum open the water KO drum dump valve (UZV-201).

2.5 Additional information and requirements

- The CO₂ absorber gas feed shut-down valve (UZV-203) must be quick closing (< 3 seconds) and slow opening (> 15 seconds).
- The CO₂ absorber gas bypass control valve (PCV-205) valve must open in the same period in which the CO₂ absorber gas feed shut-down valve (UZV-203) closes to prevent pressure build up.



- The CO₂ absorber gas bypass control valve (PCV-205) valve must be provided with a mechanical minimum stop to prevent the valve from closing completely. Otherwise, excessive gas flow to the absorber and carbonate carry-over will occur when this valve would be closed. The CO₂ absorber is designed for part of the total loop gas circulation flow only. The setting of the mechanical minimum stop will be decided prior to start-up following the capacity test of the CO₂ absorber.
- Low level in the vacuum flasher (LZA-218-LL) must stop the carbonate pumps. This function is not shown in the logics in figures 2/3.
- The pressure differential setting for PDZA-206 of 0.02 bar assumes that the pressure drop over the CO₂ absorber gas feed valve UZV-203 exceeds 0.02 bar even if the feed valve is fully open. These settings may need to be adjusted prior to start-up if the pressure drops turn out to be lower.
- The minimum flow setting for FIZA-213 of 575 t/h is for the condition that high activity catalyst is loaded in the EO reactor. When the catalyst is changed to another type, the trip setting has to be adjusted subject to advice and approval by the licensor.
- The CO₂ absorber bypass valve (PCV-205) is not available for operator adjustment as long as the shut-down system has not been reset. Once the system is reset the bypass valve can be controlled, gradually and carefully, to maintain sufficient pressure drop over the unit and to drive the gas feed to the CO₂ absorber. The tuning parameters of the bypass valve must be set to prevent rapid valve closing action.
- The carbonate pump recycle control valve (FCV-222) will open automatically in case of a trip of the carbonate shut-down system. It is desirable to keep the lean carbonate pump in operation during a short shut-down in order to maintain liquid pressure on the lean carbonate valves preventing back flow of loop gas due to leakage.
- The steam control valves should close in about 20 seconds to minimise the upset of the process steam system. The steam control valves must remain closed during a shut-down to prevent over-concentration of the carbonate solution.
- In case of a long shut-down the carbonate could be stored in the storage tank. Before charging the carbonate in the storage tank the dissolved gases must be stripped out completely to prevent an explosive mixture in



the vapour cap of the tank. Therefore before the carbonate solution is sent to storage, it should be circulated and stripped lightly for about 30 minutes. Be careful not to over-concentrate the solution.

- The trip setting for PDIZA-211 is tentatively set on 0.2 bar. It is recommended to adjust this trip setting after start-up once the typical pressure drop is known.



3 START-UP

The start up procedure is executed in two stages:

- Make sure all trip conditions are safe. Make sure the gas feed valve is closed. Start the carbonate pumps and establish lean carbonate flow over the minimum flow recycle. Start anti-foam dosing. Reset system by HS-231. After reset of the carbonate flow, the carbonate circulation flow must be increased to clear FIZA-213 within 3 minutes. If a trip occurs while the carbonate flow has not yet cleared the trip setting, the system needs to be reset again.
- Introduce gas feed, assuming the recycle gas compressor is running, by resetting HS-232. Gas feed should be increased slowly to prevent foaming problems due to rapidly increasing gas feed and to avoid insufficient pressure drop over the CO₂ absorber.

The initiators and the actions of the CO₂ shut down system can be seen in the logics in figure 2. It can also be seen how the initiators are cleared when starting up the plant. For the lean carbonate flow a special feature has been implemented to ensure a smooth and safe start up of the plant. A 3 minute on delay allows the operator to increase the lean carbonate flow to above the trip setting slowly, such that no foaming and flow upsets will occur. Also a 30 seconds on delay on the input from the flow reading makes sure that fluctuating flow measurements will be ignored and only a continuous, steady flow will be used as input to the trip system. In case the lean carbonate flow can be increased to above the trip setting in less than 3 minutes, the special features and time delays will be by-passed in the logic.

4 SYSTEM SKETCH AND LOGIC DIAGRAMS

Refer to next pages for a system sketch and logic diagrams including trip settings.



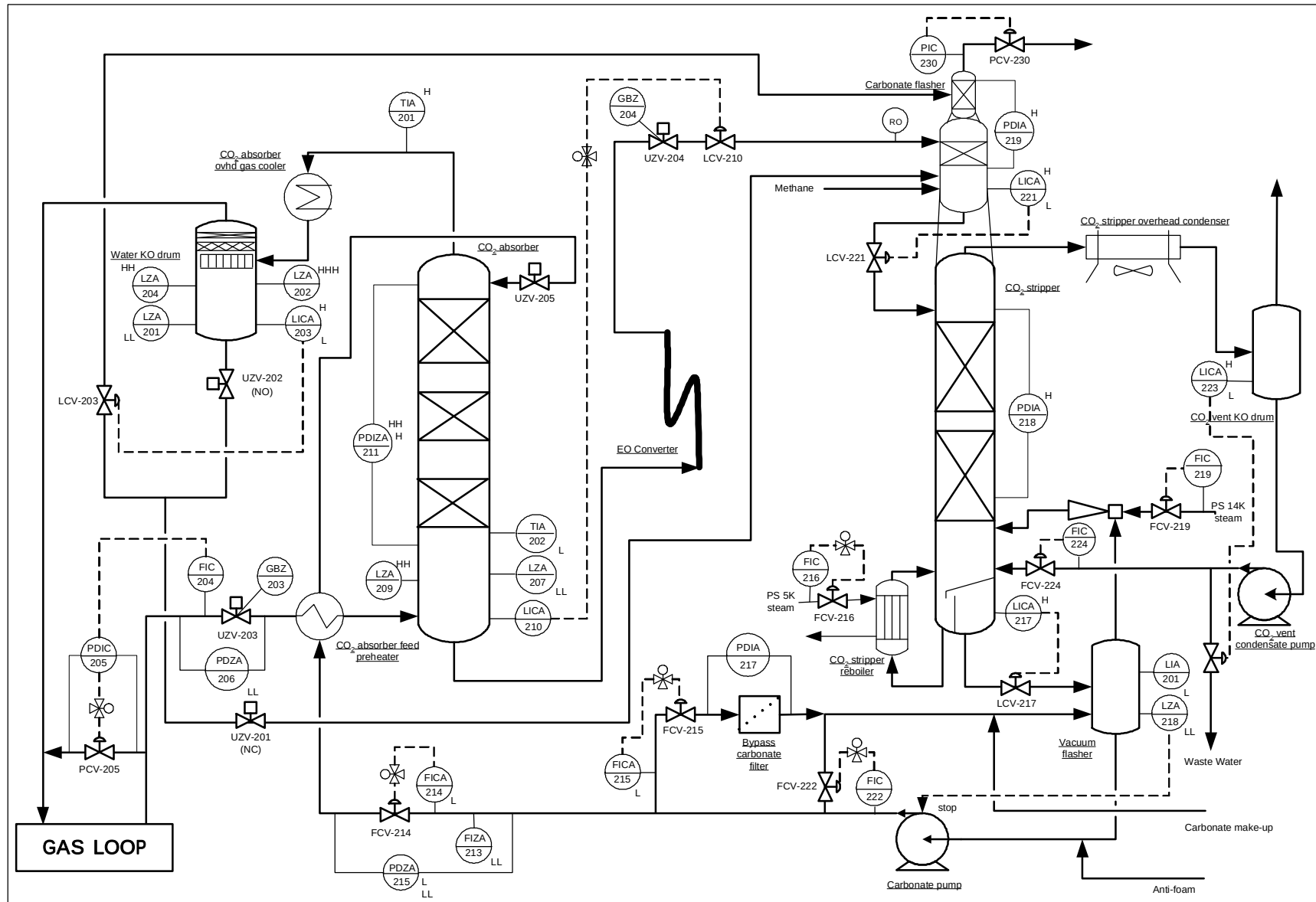


Figure 1: CO₂ removal unit sketch



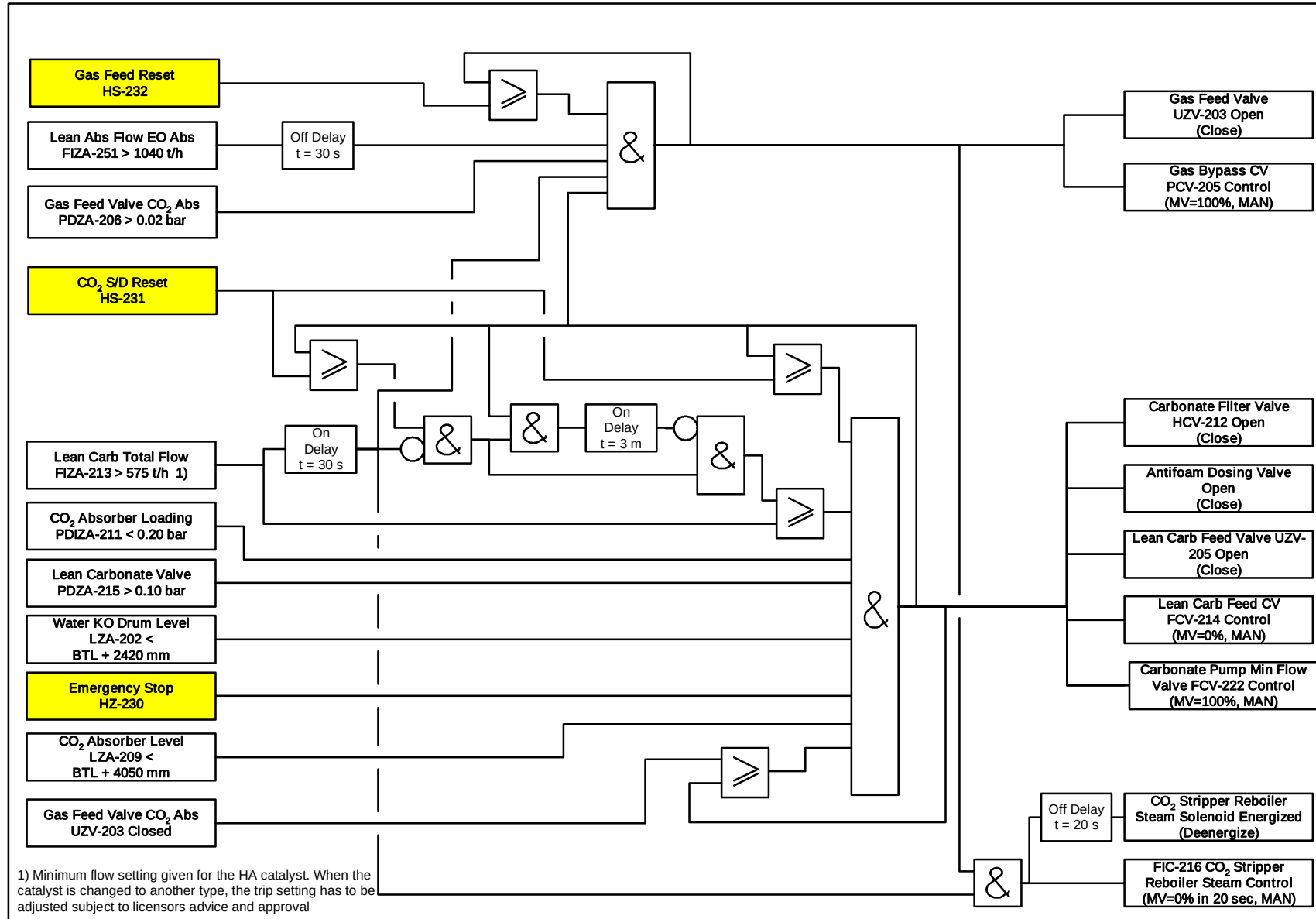
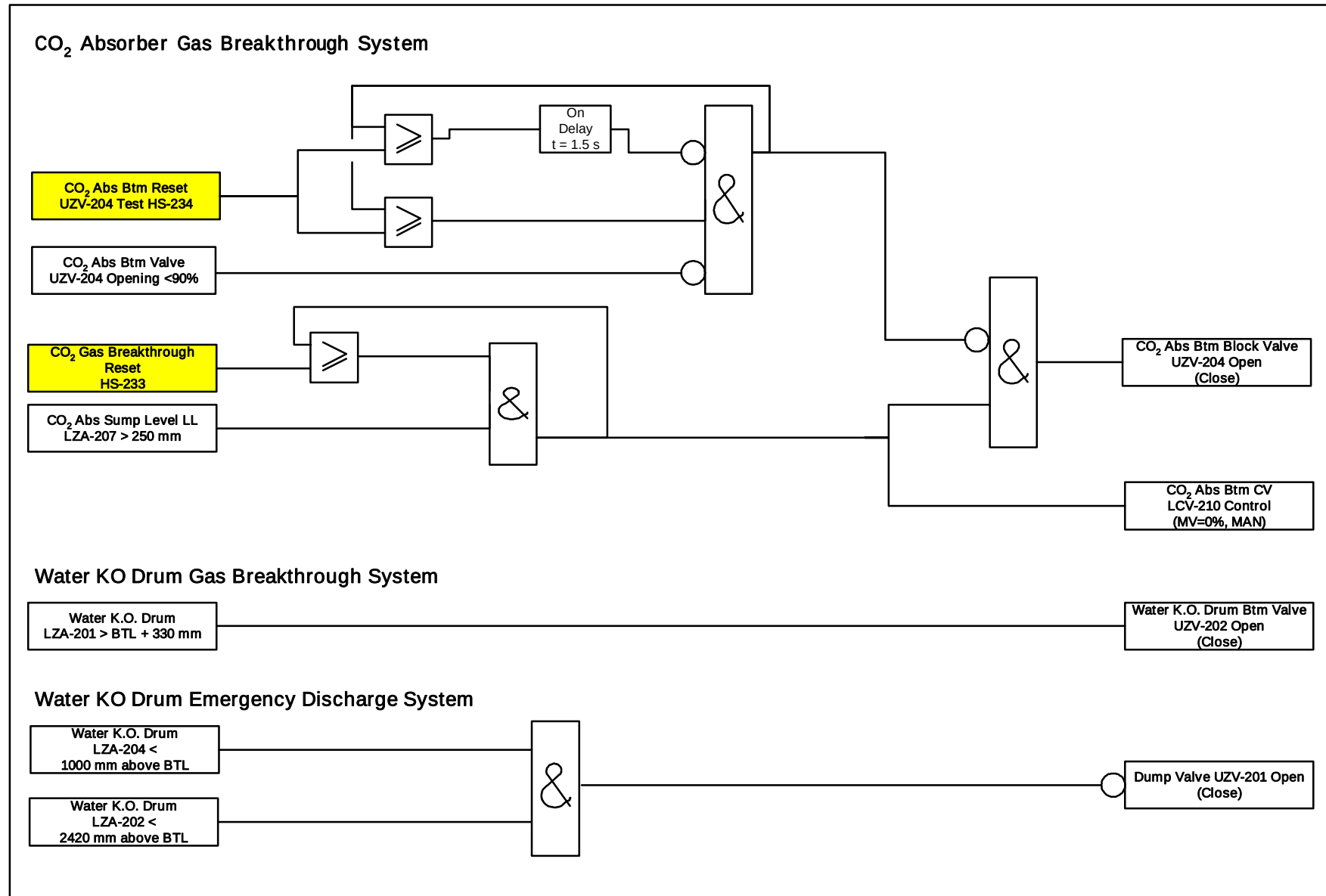


Figure 2: CO₂ shut-down system logic and trip settings - I



Figure 3: CO₂ shut-down system logic and trip settings - II