

SHELL INTERNATIONAL CHEMICALS B.V.
AMSTERDAM - THE NETHERLANDS

SHELL EO/EG PROCESS MEMORANDUM 113

SUBJECT : GLYCOL REACTOR SHUT DOWN SYSTEM

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This document describes the minimum specifications of the safeguarding system for the glycol reaction unit.

There are several hazards associated with the exothermic hydrolysis reaction of ethylene oxide and water. In order to ensure safe operation of the reactor system, certain conditions have to be assured. The main objective of these conditions is to ensure complete conversion of EO into glycols in the glycol reactor system and to prevent any situation which could jeopardise complete conversion of EO.

The protection level by the safeguarding system is based on a classification of the risks in the glycol reaction 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. The detailed engineering contractor should determine this test frequency.

Any safeguarding systems other than the safeguarding required to ensure process safety are excluded from the scope of current Process Design Package.



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1 GLYCOL REACTOR SYSTEM

The glycol reactor system includes the aqueous EO feed from the glycol reactor feed pumps, the recycle water feed from the process condensate recycle pumps, the reactor pre-heaters and the glycol reactor. Refer to figure 1 for a sketch of the system.

The aqueous EO mixture is pumped from the LE column bottom by the LE column bottoms pumps and then further pressurised by the glycol reactor feed pumps and mixed with water from the process condensate recycle pumps to obtain the desired water/EO ratio. This aqueous EO mixture is heated to 190°C in the glycol reactor pre-heaters 1, 2 and 3 and is then fed to the glycol reactor.

Conversion of EO to MEG is a liquid phase reaction. Formation of a vapour phase in the reactor must therefore be avoided. The minimum reactor pressure to keep the reactor contents in the liquid phase is a function of the temperature and the EO content. With a residence time in the reactor of three minutes, the conversion of EO is essentially one hundred percent.

The basic requirement for the EO reaction is a complete conversion of EO into glycols. This requirement is realised by an excess water flow, which also provides heat sink for the exothermic reaction, and by maintaining the inlet temperature of the reactor at a certain value. A too low temperature will slow down the reaction, whilst at high temperatures part of the EO will vaporise and pass through the reactor unreacted. To ensure that the reaction takes place in the liquid phase, the reactor pressure should be safeguarded. The primary variables for the EO conversion to be monitored and controlled are:

- Reactor feed flow
- Process condensate feed flow
- Inlet temperature of reactor
- Reactor pressure

The glycol reactor shut down system is based on the above primary variables and the potential danger of loss of either EO or water feed to the reactor.



The safeguarding system also protects against back flow in case of loss of reactor feed or water feed to the reactor.

In case of a shut-down of the reactor feed, the oxygen feed to the plant will have to be shut down by the operator, if the glycol reactor system can not be restarted within a reasonable minutes.

The safeguarding requirements described in this process memorandum primarily focus on the glycol reactor system. For details of the oxygen feed flow control and shut-down system refer to PM 111. For details of the LE column bottoms pump isolation and safeguarding system, the glycol reactor feed pump isolation and safeguarding system and the LE column safeguarding system refer to PM 114.

2 AUTOMATIC SHUT DOWN SYSTEM

Refer to figure 2 for the logic diagram of the glycol reactor shut-down system.

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

All 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. However, some 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 glycol reaction provides appropriate safety actions for the various possible abnormal operating conditions. The following situations can be distinguished:

1. Shut down of the reactor feed flow only
2. Total glycol reactor shut down

2.1 Shut down of the reactor feed flow

Abnormal operating conditions related to the reactor feed will isolate the reactor feed stream from the reactor. The water feed will continue, the reactor control system will continue its normal control function.

A trip of the reactor feed flow only will be initiated in case of:

1. Low reactor feed flow (FZA-407-LL).
2. Low differential pressure across the reactor feed control valve (PDZA-409-LL).
3. High or low reactor inlet temperature (TZA-413-HH, TZA-414-LL).
4. Low reactor pressure (PZA-415-LL).
5. Shut down of both glycol reactor feed pumps (refer to PM 114 for details).

On activation of the reactor feed flow shut down system the following actions will take place:

1. Reactor feed control valve and block valve are closed (FCV-408 and UZV-402).

If the glycol reactor feed pump is still running, it will continue to do so through the minimum flow recycle. Since the pump power will lead to a significant temperature rise of the aqueous EO and since the recycle is a closed loop over the LE column bottom, it will be required to increase the flow through the aqueous EO shut-down cooler to keep the temperature under control. In case



of loss of cooling water, fire water should be connected to the aqueous EO shutdown cooler.

Since aqueous EO is a reactive mixture the reaction will proceed in the aqueous EO system, and ultimately will run away, in case cooling would not be provided.

For details on emergency cooling refer to PM 114.

2.2 Glycol reactor shut down

Abnormal operating conditions indicating a potential loss of the process condensate flow will trip both the reactor feed as well as the process condensate water flow. If running, the reactor and process condensate feed pumps will continue to operate through their minimum flow recycles.

The glycol reactor shut down system will be initiated in case of:

1. Low water flow (FZA-410-LL)
2. Low differential pressure across the water control valve (PDZA-412-LL)
3. Low liquid level in water surge drum (LZA-421-LL)
4. Trip of both process condensate pumps
5. Emergency trip (HZ-430)

To allow operation at 40% turndown, a low aqueous EO feed allows a lower process condensate feed flow than under normal conditions.

On activation of the glycol reactor shut down system by any of the above initiators the following actions will take place:

1. Reactor feed control and block valve are closed (FCV-408, and UZV-402).
2. Process condensate control and block valve are closed (FCV-411 and UZV-404).
3. The block valve at the outlet of the reactor is closed (UZV-407).



4. The steam supply to preheater 3 is cut off by de-energising the solenoid valve on the flow control valve (FCV-417) due to a loss of water feed flow (indirect action).

In order to keep the inventory as small as possible, the shut-off valves for the reactor (FCV-408 and UZV-402) and process condensate flow (FCV-411 and UZV-404) should be installed immediately up-stream of the mixing point, which in turn should be installed at minimum distance from preheater 1.

As a precautionary measure the operator shall be instructed to vent steam from reactor preheater 3 upon a glycol reactor trip. This should be done to prevent continued heating in case the steam supply valve (FCV-417) would be leaking.

Note that the process condensate pumps will be tripped by a separate action in case of low level in the water surge drum.

Contractor shall consider the potential risk of backflow of aqueous EO into the recycle water line when determining the shut-off pressure of the glycol reactor feed pump and the process condensate recycle pump.

3 START-UP GLYCOL REACTION SYSTEM

Due to the absence of major buffer volume between the EO and EG sections of the plant, start-up of the glycol reactor should be carefully scheduled in conjunction with the start-up of the EO reaction. For start-up of the glycol reactor, the following procedure is required:

1. Start the process condensate recycle pump over its minimum flow by-pass. The low differential pressure trip (PDZA-412-LL) is now cleared.
2. Close PIC-419 in the outlet of the reactor on manual. Set FIC-411 on 0 t/h. Reset HS-431 which opens the process condensate block valve (UZV-404), enables the process condensate control valve (FCV-411) to be controlled by FIC-411 and opens the reactor outlet block valve (UZV-407). While FCV-411 is still closed on manual.



3. Gradually open PCV-419 and FCV-411 and establish water flow through the reactor. Open steam to preheater 1 to heat up the water feed to the reactor and concentrators. When pressure builds up in the concentrators establish the water recycle. Put PIC-419 and FIC-411 in automatic control. Increase water flow through the reactor to a rate high enough to clear the minimum flow shut-down (FZA-410-LL) and at a pressure high enough to clear the minimum pressure shut-down (PZA-415-LL).
4. Introduce steam to reactor preheater 3. Line up the water recycle through preheater 2. Increase reactor inlet temperature to clear the low temperature trip (TZA-414-LL). Adjust carefully to avoid a high temperature trip (TZA-413-HH).
5. Start the LE column bottom pump circulating over the LE column and wait until aqueous EO arrives. Initially, the aqueous EO will hardly contain any EO but this will increase with increasing oxygen feed rates.
6. When aqueous EO starts to arrive, although at low concentrations, start the glycol reactor feed pump (suction valve UZV-401 should be open) over the minimum flow by-pass to the LE column bottom. The low differential pressure (PDZA-409-LL) will now be cleared.
7. The reactor feed can now be started by reset HS-432, which automatically starts a 30 second override of the low low reactor feed flow trip (FZA-407-LL), and which opens the reactor feed block valve (UZV-402) and enables the reactor feed control valve (FCV-408) to be controlled by FIC-408.
8. Increase reactor feed flow through the reactor to a rate high enough to clear the minimum flow shut-down (FZA-407-LL). Increase water feed to the reactor to keep FZA-410 cleared.
9. Adjust set points of controllers according to required operation.
10. Keep a close eye on reactor inlet temperature to avoid temperature trips. Fluctuations in reactor recycle flow may cause temperature fluctuations in reactor feed preheater 2.

4 SYSTEM SKETCH AND LOGIC DIAGRAMS

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



Figure 1 - Glycol Reactor System Sketch

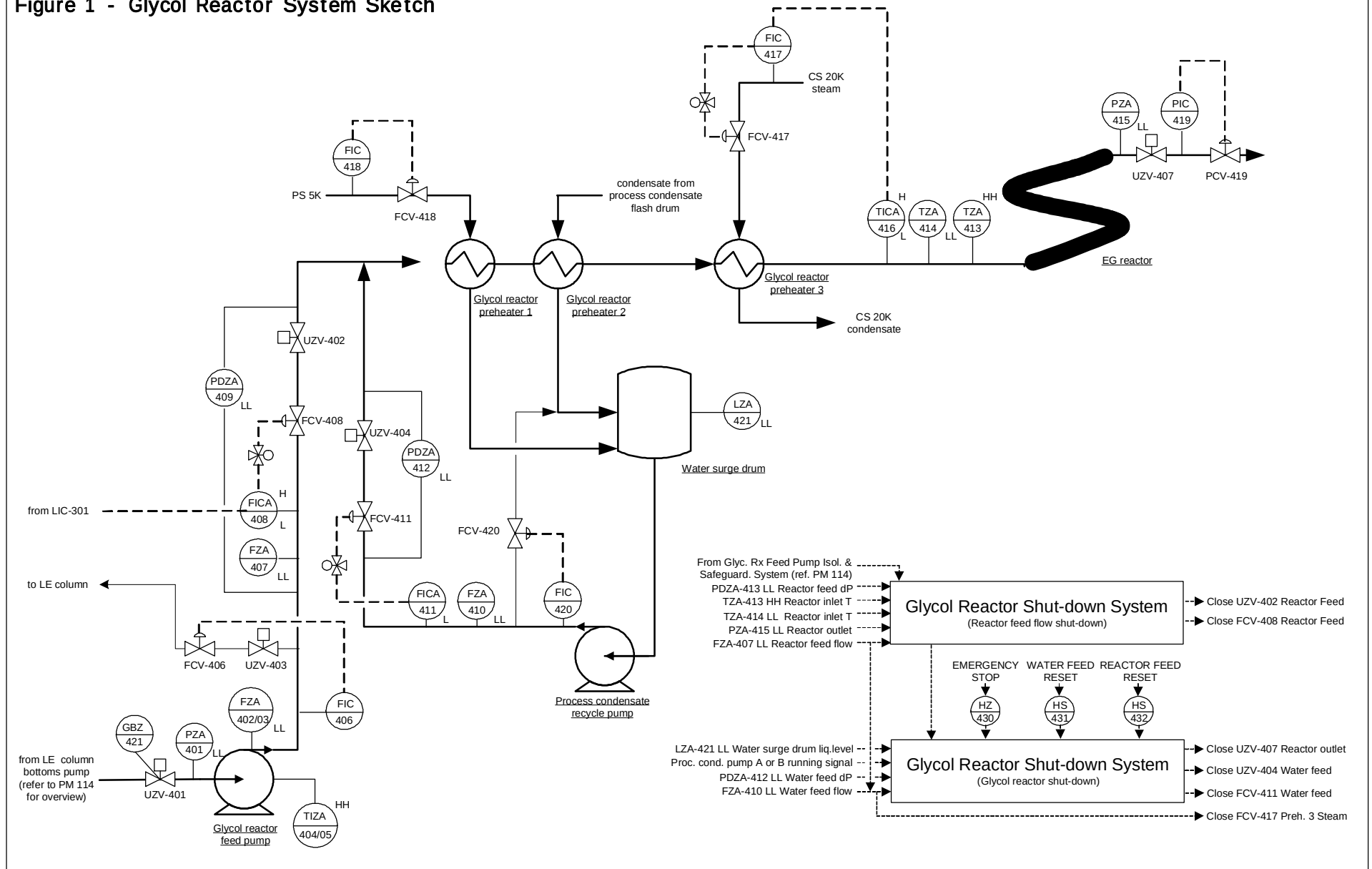


Figure 1: Glycol reactor system sketch



Figure 2 - Glycol Reactor Shut down System

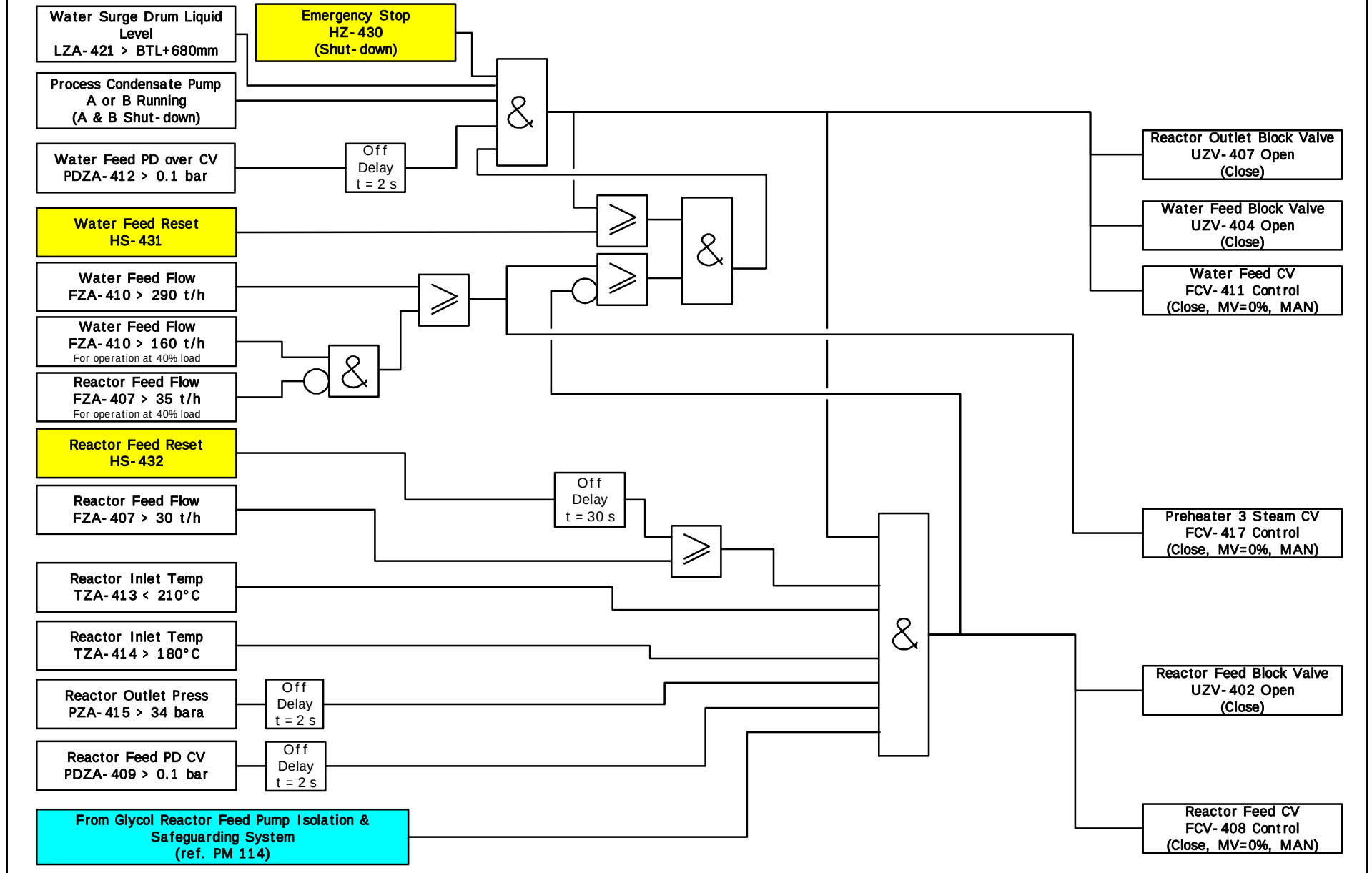


Figure 2: Glycol reactor shut down system logic and trip settings

