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SHELL EO/EG PROCESS MEMORANDUM 111

SUBJECT : OXYGEN FEED FLOW CONTROL AND SHUT-DOWN SYSTEM

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This document describes the minimum required design specification of the oxygen feed flow control and shutdown system.

In the process pure oxygen is continuously mixed with an ethylene containing hydrocarbon gas. Measures have to be taken to avoid or prevent oxygen concentrations exceeding the flammable limit anywhere in the process. This requirement can not be met in the oxygen mixing nozzle where oxygen concentrations range, by definition, from 100 percent to approximately 8.0 % m/m, a typical figure for the EO reactor feed.

The protection level by the oxygen shut down system described in this memorandum is based on a classification of the various process risks 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 process risk protection, cost and operability. In order to ensure adequate safeguarding, the trip initiators and actuators need to be field tested regularly. This test frequency should be determined by the detailed engineering contractor.

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 INTRODUCTION

The design of the oxygen mixing nozzle promotes rapid dilution of the oxygen and minimises the space in which the oxygen concentration exceeds the flammable limits, which, combined with measures taken to avoid ignition sources, ensures a safe mixing operation.

The purpose of the oxygen feed flow control and safeguarding system is:

1. To control the oxygen feed rate to the recycle gas stream in a reliable manner.
2. To shut off the oxygen feed in a safe way when certain abnormal process conditions are reached.

2 GENERAL DESCRIPTION

2.1 Oxygen feed flow control

The oxygen feed flow control system ensures that the oxygen supply rate will not increase beyond the maximum allowable values in case of:

- instrument failure
- inadvertent manipulation of the controller

The above requirements are met by the use of a middle-of-three flow transmitter installation for control, minimising the risk of failure of the measured value of the oxygen flow rate as seen by the flow controller. Safeguarding features are also provided to prevent hazardous conditions in the oxygen mixing system.

The following features are considered essential for monitoring the flow control system within the DCS:

- a. The rate at which the oxygen feed flow setpoint can be increased by the operator is limited via a ramp function. This means that any step change in setpoint will result in a timed ramp response from



the DCS. The rate of the ramp must be less than the trip setting for the rate of change of the flow.

- b. The DCS must provide the middle-of-three selection algorithm for the process measurement.
- c. A central sequence of events recorder (SER) shall be provided for all plant events, including for all other safeguarding systems. All equipment that see or initiate events, such as the DCS and PLCs, are to have all events time-stamped in that equipment and sent to the SER for event recording. The SER shall have the capability to sort and analyse these events by, at least, unit, time, equipment and type and be able to store at least 10,000 alarms and events in history. Provision is to be made in software for easy transfer of event history to a PC for further storage and analysis.

2.2 Oxygen shut-down system

Refer to figures 1 for a 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.

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 both 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 objectives of the oxygen shut-down system are:

1. To stop the oxygen supply in case a certain condition indicates that a hazardous situation may develop in the process.
2. To prevent at all times, including start-up and shut-down, mixing of oxygen and hydrocarbons in flammable concentrations except in the immediate down-stream space of the mix nozzle. During normal operation the special features of the mix nozzle prevent mixing of oxygen and hydrocarbons in the mix nozzle and oxygen feed line.

Upon any abnormal, potentially dangerous, situation, the oxygen safeguarding system will stop the oxygen feed and starts the nitrogen purging operation of the mix nozzle and prevents the start of the oxygen feed.

Introduction of nitrogen during start-up and shut-down is necessary to prevent hydrocarbons from entering the mix nozzle spargers and oxygen piping.

Mixing of oxygen and hydrocarbons, when the plant is shut-down, is prevented by a double-block-and-double-bleed system.

To prevent abnormal behaviour of the catalyst at re-start-up, it is required to stop the moderator supply when the oxygen supply has been tripped. The safeguarding system will cut off the moderator injection automatically.

For both high activity and high selectivity catalyst the variable trip settings for the oxygen concentrations require frequent re-adjustment as the flammable limits decrease due to the temperature rise required to compensate for ageing of the catalyst. The controlling flammable limit can be found at the reactor inlet (HA and HS).

The fixed trip is set at the flammable limit at the reactor worst-case inlet condition, i.e. the lowest value during catalyst lifetime. This trip setting will not be adjusted during catalyst life.



3 PRINCIPLE OF OPERATION

3.1 Normal operation

From battery limit the oxygen, before entering the oxygen mix nozzle, will pass in the following order:

1. battery limit block valve (UZV-101)
2. the oxygen filter
3. a pressure control valve (PCV-101)
4. a flow meter orifice (FT-101)
5. a flow control valve (FCV-101)
6. two quick closing, spring loaded, tight shut-off valves (UZV-102 and UZV-103) in series, with bleed valves UZV-104 and UZV-105.
7. a non-slam type non-return valve

During normal operation, the battery limit block valve UZV-101, and shut-off valves UZV-102 and UZV-103 will be fully open. Bleed valves UZV-104 and UZV-105 and the nitrogen valves UZV-106, UZV-107 and HCV-107 must be closed. A graphics view on the DCS will show positions of all relevant valves and process variables for ease of overview by the operator.

3.2 Shut-down

When a trip is initiated, the following actions will take place:

- The control valve FCV-101 and the block valves UZV-102 and UZV-103 close. The block valves must close in less than one second. Subsequently the vent valves UZV-104 and UZV-105 open to release the oxygen, trapped between respectively FCV-101 and UZV-102 and UZV-102 and UZV-103, via vent lines to a safe location in the atmosphere. Simultaneously, valves UZV-106 and UZV-107 will open and nitrogen from the buffer vessel is introduced directly downstream of the last block valve UZV-103 to purge the system. Initiation of the trip system will actuate process alarms in the DCS system, . The process alarm system includes valve position mismatch



alarms for all trip valves, to warn operators of potentially stuck valves. The DCS audible alarm will be of the highest priority to ensure immediate operator attention. The alarm display screen on the DCS will show all alarm conditions.

- The sequence of events record will show all events in the system in chronological order for cause analysis.
- The flow rate of nitrogen shall initially be high to quickly clear the down-stream piping and the mix nozzle sparger rings of oxygen. The purge nitrogen flow rate must never exceed the design oxygen flow rate (DOF), since this nitrogen is displacing oxygen inventory into the recycle gas stream. The system has been specified such that the total volume of nitrogen introduced during the first five seconds is at least the volume of oxygen present in the oxygen line and mix nozzle sparger rings. The nitrogen purge flow rate will range from approximately 80% to 60 % in the first 5 seconds due to RO-102. After 5 seconds the nitrogen flow rate decreases to a flow rate of about 0.05 times DOF due to RO-104.
- This small purge flow supplied from the N₂ storage vessel, should be adequate to keep the oxygen piping between UZV-103 and the mix nozzle free from hydrocarbons. If the shut-down is of long duration, the nitrogen purge flow may be decreased to about 0.005 times DOF. This is done by unlocking and opening valve HV-108 and closing and locking valve HV-109 such that the nitrogen flow is set by RO-103. It is recommended to maintain this very small purge flow of nitrogen as long as the recycle gas loop is not depressurised.
- Above purge rates are set by the various restriction orifices.

3.3 Start-up

To allow charging of ethylene and, depending on the circumstances, methane to the gas loop prior to start-up of the oxygen feed and to allow



pre-soaking of the catalyst with moderator, the gas feed to the control valves can be enabled by HS-103.

The mixing of hydrocarbons with oxygen anywhere else than in the down-stream part of the mix nozzle must be prevented. After a shut-down, hydrocarbons may be present in the oxygen feed line down-stream of block valve UZV-103 and will certainly be present in the mix nozzle sparger rings. It is imperative that these parts are free of hydrocarbons before oxygen is admitted. This is achieved by purging with nitrogen at an adequate rate for a sufficient length of time. Experience has shown that a 3 minutes nitrogen flow equivalent to approximately 0.26 times DOF will be adequate to fulfil this requirement. Thus RO-101 must be sized to allow this flow rate at the minimum available nitrogen pressure, which is normally the set point of pressure controller PCV-110.

It is vital, however, to determine experimentally the actual required purge flow before the first actual plant start-up.

During the start-up procedure a trip could occur, in which case the system should be purged with nitrogen automatically. Therefore a certain inventory of nitrogen is always available in the nitrogen buffer vessel, which allows safe shut-down, even if the nitrogen supply has failed. Low pressure of nitrogen in the buffer vessel (PIZA-109) initiates a trip when the plant is operational. It also prevents the introduction of oxygen.

The following sequence of actions has to be taken for start-up:

- Start-up nitrogen is introduced via valve HCV-107 that is operated by HIC-107 from the DCS. A 3 minute timer starts as soon as the nitrogen purge flow rate exceeds the minimum required purge flow rate of FIZA-106, preventing further action until it times out. It is possible to close the nitrogen purge valves UZV-106 and UZV-107 via DCS reset button HS-101 immediately after FIZA-106 has become healthy.
- The oxygen double block and bleed valves can now be reset via reset button HS-104, provided that :



- a. The pressure in the nitrogen buffer vessel has increased sufficiently so that PIZA-109 is cleared. In order to fill the nitrogen buffer vessel a bypass is used to speed up the procedure, thus ensuring that nitrogen from the buffer is available for any subsequent trip during the start-up of the oxygen feed.

The nitrogen storage vessel has a volume that corresponds to nitrogen purging for start-up and shut-down. When the oxygen supply is shut-down the nitrogen storage will provide a continuous nitrogen purge of about 0.05 DOF. Shortly after shut-down, the nitrogen safeguarding compressor will automatically start to make up to the nitrogen storage for the 0.05 DOF nitrogen purge flow.

If for some reason the nitrogen vessels would ever be depleted while the gas recycle loop still contains loop gas, hydrocarbons could flow back into the oxygen mixing nozzle and related piping system. If this situation were ever to occur or is suspected to have occurred, the vessel must be thoroughly purged and refreshed and a sample of the nitrogen vessels must be taken prior to oxygen start-up to assure that the nitrogen is not contaminated.

- b. The valve FCV-101 remains fully closed (GBZ-101). This valve will already be closed and on manual, an action initiated by the oxygen trip system upon shut-down. The DCS will not allow opening of this valve whilst the oxygen system is shut down.
- c. An adequate nitrogen purge flow is maintained via HCV-107, monitored by FIZA-106, which, during start up, overrides FIZA-102 and clears the differential pressure over the oxygen mixing nozzle PDIZA-111 as well.



- d. An adequate pressure drop over FCV-101 is available to ensure positive oxygen flow, as long as the oxygen flow is below the lower trip setting of FIZA-102.
- e. All other trip initiators in the process are healthy. Refer to Figure 2 and to PFDs for other trip initiators. With respect to trip of the recycle gas compressor, please note that all compressor shut down initiators should first activate the oxygen shut down system and only after 5 seconds delay trip the compressor. Both in case of axial displacement trip as well as in case of loss of sealing trip there shall be no time delay. On all other oxygen trip events the compressor must continue to run.

- On reset of the safeguarding system by HS-104, the DCS manual control station HIC-107 is disconnected via solenoid valve SV-107 and a permanent signal will keep HCV-107 open (SV-107 energised).
- Oxygen can now be introduced into the mixing nozzle by slowly opening FCV-101. During this period the nitrogen purge via HCV-107 is maintained. When a sufficiently high oxygen flow (about 0.20 DOF) has been established, FIZA-102 LL will become healthy. Nitrogen flow is still maintained until the oxygen flow is sufficiently high (FIZA-102 > L, about 0.26 DOF) to allow automatic reset of solenoid valve SV-107 to the de-energised position and thus connecting HC-107 and HCV-107 again. When the oxygen flow has increased beyond FIZA-102L, the delta P over FCV-101 is no longer a trip initiator.
- This will transfer control of HCV-107 back to the DCS via HIC-107. The nitrogen flow must be gradually decreased to zero by DCS, over a period of three minutes. The system is now operational. The operator can intervene during the automatic ramp of HCV-107 (and later) at any time to manipulate this valve using HIC-107 according to process requirements.

When SV-107 is energised, the maximum flow allowed by RO-



101 will be fed to the mixing nozzle, assuming that the nitrogen buffer vessel has been filled to its maximum pressure.

During start-up an event could occur which requires manual operator intervention by pushing emergency shut down button HS-102. The nitrogen required for start-up should remain in place and closing of HCV-107 should be prevented.

4 INSTRUMENT ENGINEERING DETAILS AND SPECIFICATIONS

The following requirements are specific to the oxygen feed flow control and shut-down system.

4.1 General requirements

The following requirements apply to all instruments in oxygen and nitrogen service as part of the oxygen feed flow control and shut-down system.

4.1.1 The primary devices for flow measurement shall be a square edge orifice plate with flange taps, calculated in accordance with ISO 5167 "Measurement of fluid flow by means of orifice plates". If possible this orifice assembly shall be located in a vertical line. Where this is not possible the preferred orientation of the differential pressure type flow transmitters would be with both sets of sensing taps located under 45° upwards with transmitters located above the pipe such that the sensing legs drain completely.

4.1.2 All transmitters, including flow, shall have a linearised output signal (SQRT extraction in the transmitter) and shall conform generally with the transmitters selected for the overall project. However, they shall be supplied degreased for oxygen service and with an appropriate fluid filling in the diaphragm capsule assembly, e.g. "Fluorolube".

4.1.3 All components in this service are to be made of stainless steel, in accordance with the piping classes and will be degreased to the standards required for oxygen service. Pressure gauge dials shall be clearly marked "Degreased for oxygen service - test with oil free air or



inert gas”.

- 4.1.4** Lines and equipment within the battery limits, which come in contact with oxygen feed, shall not be made of carbon steel. Stainless steel is required for the nitrogen line from the buffer vessel into which oxygen could possibly flow back. If rust or scale were present in such a line, it could be blown into the oxygen line and possibly cause a spark or even plug the nozzles of the mixing nozzle.
- 4.1.5** All controls/measurements/alarms shall be within the DCS system. For some trip transmitters it is required to show the measured value on the DCS. The signal should arrive from the PLC.
- 4.1.6** Solenoid valves shall not have mechanical manual reset features as the necessary start-up interlocks are incorporated in the functional logic system/start-up sequence.
- 4.1.7** Check valves in oxygen service must be of the non slam type. The preferred type is the plate-disc type. Dual plate type check valves can be used provided that the assembly of the check valve is fire safe. These must therefore be of the lug style or single flange style. Piston type check valves may also be used.
- 4.1.8** For additional information please refer to process memorandum 115 on "Process control and safeguarding systems".
- 4.1.9** The rate of change (ROC) trip for the oxygen feed flow is to be configured by calculation of the rate of change in the PLC. The purpose of the ROC trip is to prevent a rapid increase of the oxygen flow that would lead to exceeding the flammable limit in the loopgas. Note that the response time of the oxygen analysers must be below 20 seconds and that therefore any increase will only be detected with a delay. The ROC trip setting should be 4.2 t/h and is based on the requirement to be able to run the plant at a margin to flammable limit of 0.5%. Thus in case of a rapid increase of the oxygen flow rate the ROC trip setting prevents exceeding the variable high oxygen trip setting after a 20 seconds delay. The calculation should be defined in such a way that only an increase of 4.2 t/hr or more within a 20 second period (i.e. the delay time of the



oxygen analysers) and to a value above a predefined average flow at which it was operating in the previous 20 to 80 seconds, would lead to a trip. This means that a sudden drop and restoration to the original flow, due to a pressure fluctuation, will not lead to a trip. If on the other hand, the flow would rise to a new maximum more than 4.2 t/hr above the maximum in the previous period of 20 to 80 seconds, a trip must be initiated.

The calculation method for the trip setting is defined below. The logics can be found in Figure 5. Graphs showing examples of trips and non-trips are shown in figure 6.

- Calculation of the actual flow
 - a. The oxygen flow at a certain moment is X ton/day. This value is averaged over that one second and called the actual flow. The actual flow is stored in the PLC.
- Calculation of the reference flow
 - a. The actual flow value is stored in the PLC. In the PLC a history is built up of the last 80 seconds values.
 - b. Over the oldest 60 seconds, 3 averages are calculated in portions of 20 seconds. The highest of the 3 averages is called the reference flow. This approach removes spurious trips due to “spikes” in the flow-measurement reading.
 - c. The reference flow is updated every second.
- Trip calculation
 - a. If reference flow - actual flow > 4.2 t/h a trip is initiated.

The actual flow is compared to a flow older than 20 seconds in order to ensure that the reference flow already has passed the oxygen analysers and is confirmed to be below the trip setting.

- 4.1.10** Two oxygen analysers shall be installed in the common EO reactor inlet. A fixed and a variable high oxygen trip shall be implemented in both oxygen analysers. The variable trip setting will reduce the occurrence of pre-ignitions. The fixed trip setting will avoid unacceptable high levels of



oxygen in the gas loop and prevent loss of containment. The fixed trip is set at the flammable limit at the reactor worst-case inlet condition, i.e. the lowest value during catalyst lifetime. This trip setting shall not be adjusted during catalyst life. Both analysers are connected to a common fast loop equipped with two low flow trip initiators, arranged in a 1 out of 2 configuration.

In addition to the oxygen trips a deviation alarm between the inlet analysers is added to reduce the probability of failure of the total initiator system.

One oxygen analyser shall be installed in the common outlet of the EO reactors. A variable high oxygen trip shall be implemented in the outlet analyser initiating the oxygen shut down system. The fast loop of the EO reactors outlet analyser should be equipped with a low flow trip.

The variable trip settings for the oxygen concentrations at inlet and outlet are defined based on the calculated flammable limits, observing a margin of typically 0.5 % mol, allowing operation at a margin from flammable limit of 0.8 % mol. If operation closer to flammable limits is warranted, the trip settings may be set closer to the flammable limits.

The calculated flammable limits depend on the actual process conditions and therefore change over time due to ageing of the catalyst. The variable trip settings for the oxygen concentration must be regularly compared and if necessary adjusted in line with the actual calculated flammable limits. Below table provides a summary of the design figures for oxygen concentrations and calculated flammable limits.

Establish upper and lower limits for process variables used for the reactor inlet and outlet flammable limit calculation. If the limits are exceeded, there should be an alarm and the system automatically taken out of control.

The analyser output and other parameters shall not be fed into the PLC for online calculation of flammable limits since the analysers do not have the required reliability.



	HA CAT		HS CAT	
	SOC	EOC	SOC	EOC
Oxygen inlet % mol	8.20	7.96	8.23	7.94
Flammable limit inlet % mol	9.00	8.77	9.03	8.74
Margin % mol	0.80	0.80	0.80	0.80
Variable trip s.p. inlet % mol	8.50	8.27	8.53	8.24
Fixed trip s.p. inlet % mol	8.7		8.7	
Oxygen outlet % mol	5.19	4.33	5.93	4.78
Flammable limit outlet % mol	7.43	6.48	6.95	5.83
Margin % mol	2.24	2.15	1.02	1.04
Variable trip s.p. outlet % mol	6.93	5.98	6.45	5.33

The common spare analyser must be capable of replacing any of the oxygen analysers in the safeguarding system in order to improve the reliability of the total system.

4.2 Analysis instruments

Oxygen analysers are required for the total reactor feed gas stream and the reactor outlet gas stream plus an installed spare, switchable to any of these duties. The oxygen shut-down system will be initiated by high oxygen content in either process stream.

The analysers shall be of the paramagnetic susceptibility type with recommended operating range: 0 - 10% mole oxygen. Relative accuracy within 0.5 % max. The reactor outlet shall have one dedicated analyser. The common inlet line shall have two dedicated oxygen analysers. The oxygen analysers must have a live zero to differentiate in case of malfunction between a zero signal and a zero percent oxygen reading. The analyser calibration will be performed with a prepared sample gas that has an oxygen content in the normal range of operation of the analyser. There shall be no range change switches provided as part of the analyser, calibration on air or operation on a higher range is not appropriate. Calibrate the oxygen analysers at different times to prevent common mode failure of all analysers.



In figure 2 the block “O₂ Analysers” represents the conditions of the oxygen analysers needed to prevent a trip of the oxygen shut-down system. This “O₂ Analysers” block is represented in more detail in Figure 4. This functional logic diagram explains how any of the inlet or outlet analysers can be replaced by the common spare analyser to be able to do maintenance on one of the two analysers in the common inlet or the analyser in the common outlet.

A description follows for the replacement of one of the inlet analysers by the common spare analyser. First the common spare analyser has to be connected to the oxygen shut-down system logic by an operator using the proper push button. The connection will only be established, if a number of criteria are fulfilled:

1. The O₂ concentration measured by the common spare analyser is lower than the alarm O₂ concentration of the inlet.
2. No instrument failure of the inlet analyser.
3. No instrument failure of the common spare analyser.
4. The inlet analyser is not in maintenance.
5. The common spare analyser is not in maintenance.

If all these criteria are fulfilled at the moment the operator pushes the button to connect the common spare analyser to the shut-down logic, the common spare analyser will be connected and at the same time the inlet analyser will be disconnected from the shut-down logic. Next, to enable a technician to do maintenance on the inlet analyser, an operator has to push the button to select the inlet analyser for maintenance. Only if the inlet analyser is not connected to the shut-down logic this operator action will result in putting the analyser in maintenance mode. If the analyser is in maintenance mode, the technician is authorized to start maintenance on the inlet analyser. As long as the inlet analyser is in maintenance mode, it will not be possible to connect the inlet analyser again to the shut-down logic. Once the technician has finished the maintenance work, an operator has to reset the maintenance mode. After that, it will be possible to reconnect the inlet analyser to the shut-down logic and disconnect the common spare analyser from the shut-down logic, if the following criteria are fulfilled:

1. The O₂ concentration measured by the inlet analyser is lower than the alarm O₂ concentration of the inlet.



- 2.No instrument failure of the inlet analyser.
- 3.No instrument failure of the common spare analyser.
- 4.The inlet analyser is not in maintenance.
- 5.The common spare analyser is not in maintenance.

The change-over from the outlet analyser to the common spare analyser to be able to do maintenance is exactly the same as for the any of the inlet analysers.

Besides, the analyser conditions needed to prevent a trip of the oxygen shut-down system are presented in Figure 4. The conditions for the inlet analysers are:

1. Either the inlet analyser is connected to the shut-down logic, or the common spare analyser is connected to the shut-down logic (trip in case both the inlet analyser and common spare analyser are not connected).
2. Either the inlet analyser is not connected to the shut-down logic, or in case the inlet analyser is connected to the shut-down logic, the following criteria are fulfilled:
 - a. no instrument failure of the inlet analyser
 - b. O₂ concentration inlet analyser is smaller than variable trip setting O₂ concentration inlet.
 - c. O₂ concentration inlet analyser is smaller than fixed trip setting O₂ concentration inlet.
3. Either the common spare analyser is not connected to the shut-down logic, or in case the common spare analyser is connected to the shut-down logic, the following criteria are fulfilled:
 - a. no instrument failure of the common spare analyser.
 - b. O₂ concentration common spare analyser is smaller than variable trip setting O₂ concentration inlet.
 - c. O₂ concentration common spare analyser is smaller than fixed trip setting O₂ concentration inlet.

The same conditions are valid for an outlet analyser (replace inlet with outlet in the above mentioned criteria, with the exception of the fixed trip setting). If any of the three above presented criteria is not fulfilled for any of the analysers, the oxygen shut-down system will trip.

The oxygen analyser shall be provided with:



- instrument failure alarm
- low flow alarm in the sample loop to the analyser
- calibration mode alarm
- barometric pressure compensation (flow cell pressure)

The sampling system has to be designed so that the time lag between the sample leaving the process connection and arriving at the analyser shall be well below 10 seconds. To achieve this, the sample fast loop for the reactor and reactor outlet gas analysis shall be returned to the residual EO absorber. The maximum of 10 seconds for the time lag refers only to the sample transport time. The overall lag time is the time elapsed between starting to open the oxygen flow control valve and the appearance of the oxygen on the analyser in the control room. The overall lag, as demonstrated in a plant test, may not exceed 20 seconds. The fast loop of the inlet analysers shall be equipped with two low flow trip initiators, arranged in a 1 out of 2 configuration. The fast loop of the outlet analyser shall be equipped with a low flow trip. The low flow trip initiators activate the oxygen shut down system.

Spurious spikes of the oxygen analysers might also cause nuisance trips of the oxygen shut down system. These trips could be avoided by implementing a 2 seconds time delay in the oxygen analysers. However, this is only allowed if the total system still satisfies the 20 seconds response time, including any time delays.

4.3 Pneumatically actuated control, block and vent valves

4.3.1 All the valves of the shut-down system are to be supplied:

- Degreased for oxygen service.
- With stainless steel AISI316 body.
- With trim and seat in monel.
- Without valve stem lubricators. Any connections normally used for lubricants shall be left undrilled or be permanently blanked off.
- With gland packing of teflon chevron rings.
- Vent line downstream of valves UZV-104 and UZV-105 in stainless steel.



- Nitrogen lines from the nitrogen buffer and nitrogen storage vessels to the oxygen line in stainless steel.
- Should meet local requirements for oxygen service as well.

- 4.3.2** Oxygen flow control valve FCV-101 shall be a diaphragm or piston operated, spring closing, equal percentage characteristic control, single seat globe valve fitted with a valve positioner. The valve shall be supplied as tight shut off, ANSI class VI.
- 4.3.3** Oxygen block valves UZV-102 and UZV-103 shall be full bore. For line sizes 4 inches and smaller the preferred valve is a cylinder operated, spring closing, single seat, globe valve. UZV-102 shall be installed so that oxygen flow tends to close the valve, UZV-103 shall be installed so that normal oxygen flow tends to open the valve. The valves shall close in less than one second, under conditions of normal oxygen flow. The valves shall have equal percentage characteristics, with tight shut off to meet the requirements of ANSI class VI. For line sizes larger than 4 inches pneumatically operated ball valves shall be used. The valves shall have cylinder operators with spring closing and close in less than one second. The valves shall be of the fire safe design and be fitted with teflon or glass loaded teflon seal rings, meeting the tight shut requirements of ANSI class VI.
- 4.3.4** Oxygen bleed valves UZV-104 and UZV-105, shall be diaphragm or piston operated, spring opening, single seat, equal percentage characteristic control globe valves with tight shut off to meet the requirements of ANSI class VI. It is intended that the vent valves be sized only to vent the gas trapped between the nearest block valves plus a moderate leakage flow through one of them. If the downstream block valve were to remain fully open after a trip because of mechanical seizure, sufficient pressure should result so that most of the nitrogen exits via the oxygen mixing nozzle rather than through the vent.
- 4.3.5** The nitrogen purge valves UZV-106 and UZV-107 shall be diaphragm or piston operated, spring opening, single seat, quick opening (within two seconds), line size valves, with tight shut off to meet the requirements of ANSI class VI. Make sure that the oxygen block valves actually close within one second otherwise the quick opening of the nitrogen purge valves will be useless.



- 4.3.6** The start-up nitrogen purge valve, HCV-107 shall be a diaphragm or piston operated, spring closing, single seat, equal percentage characteristic control valve with tight shut-off to meet the requirements to meet the requirements of ANSI class VI.

5 SYSTEM SKETCH AND LOGIC DIAGRAMS

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



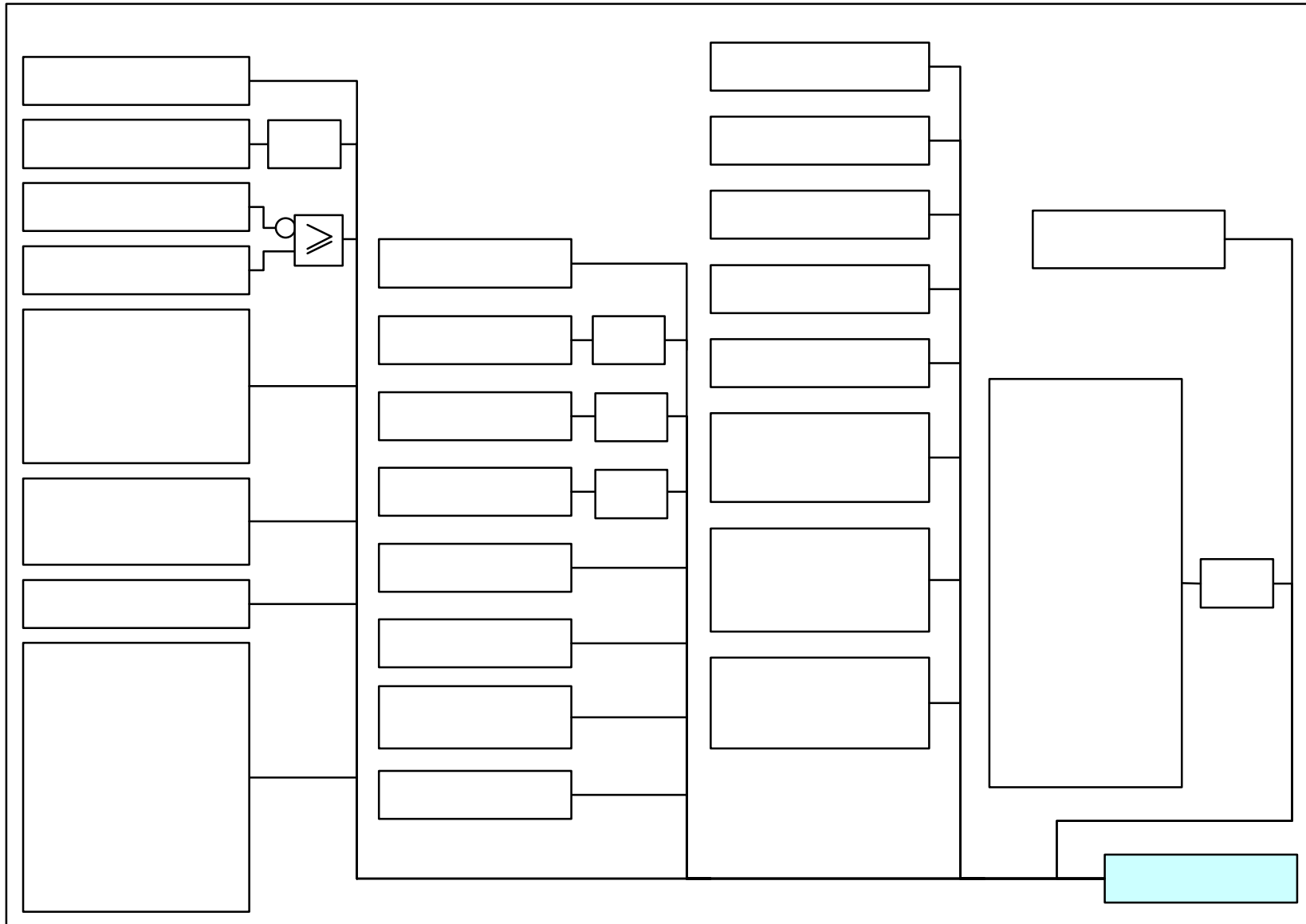


Figure 2: Oxygen shut-down system logic and trip settings - I





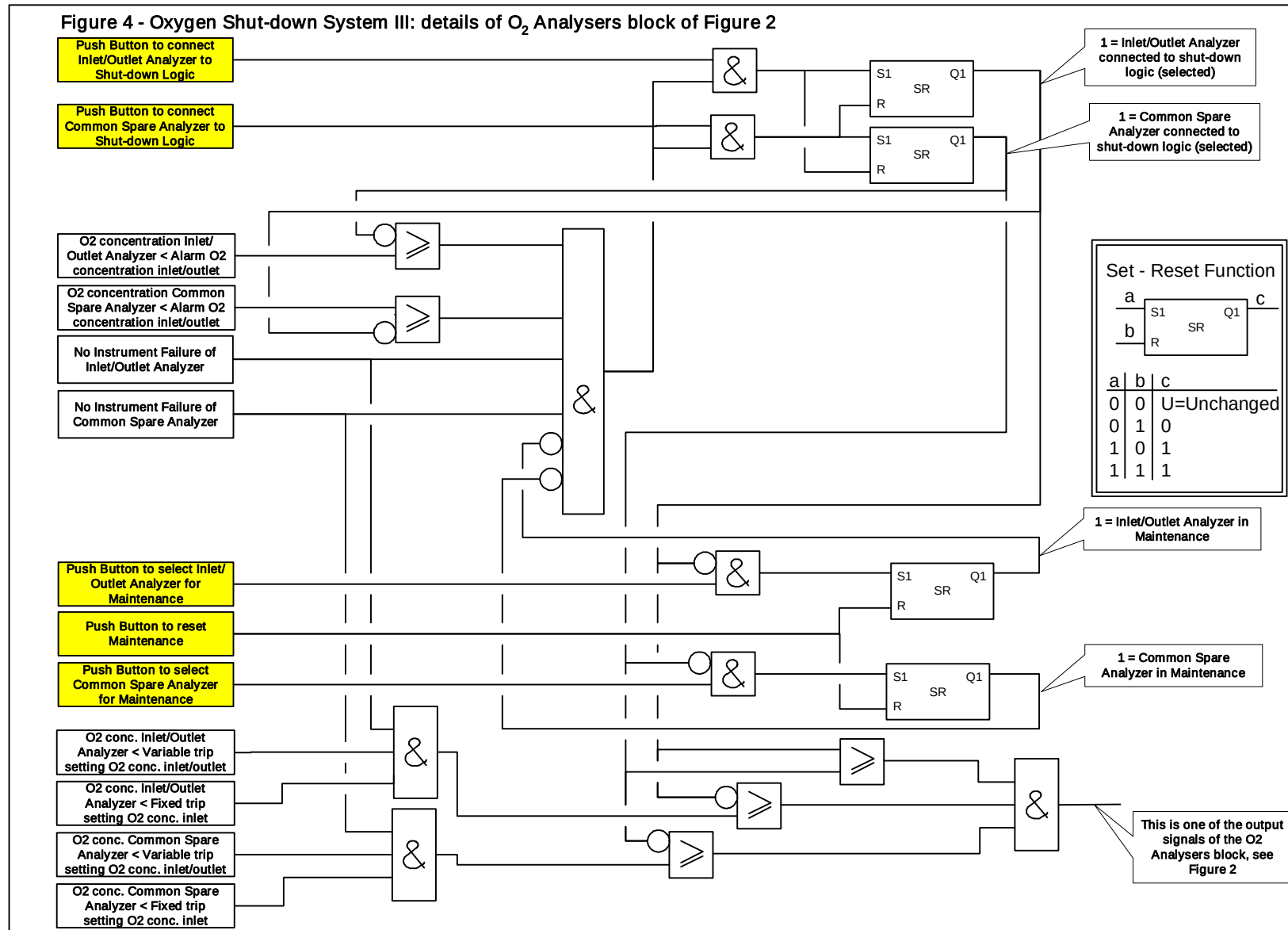


Figure 4 : Oxygen shut-down system logic and trip settings – III



Figure 5 - Rate of change

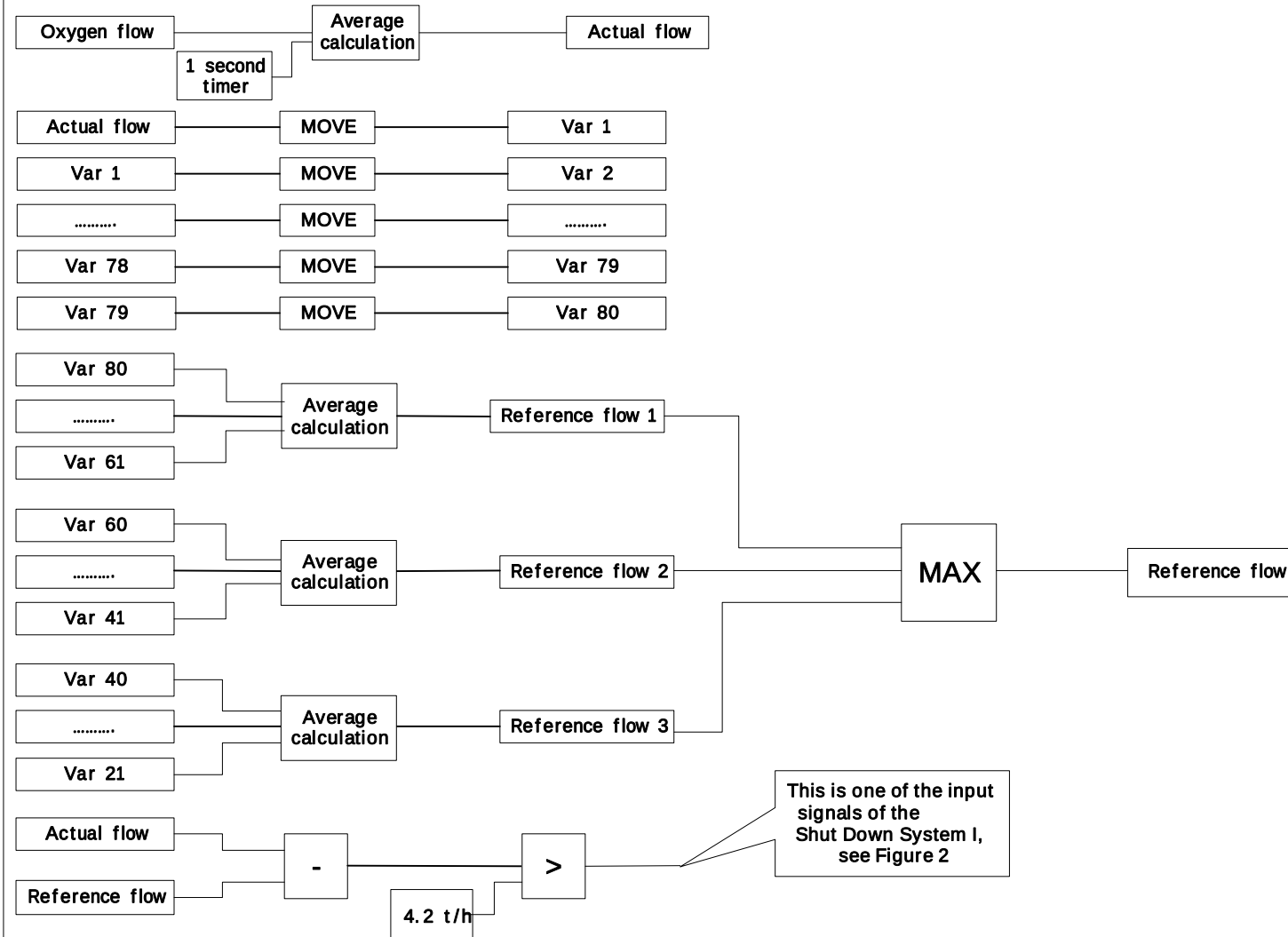


Figure 5: Oxygen rate of change logic



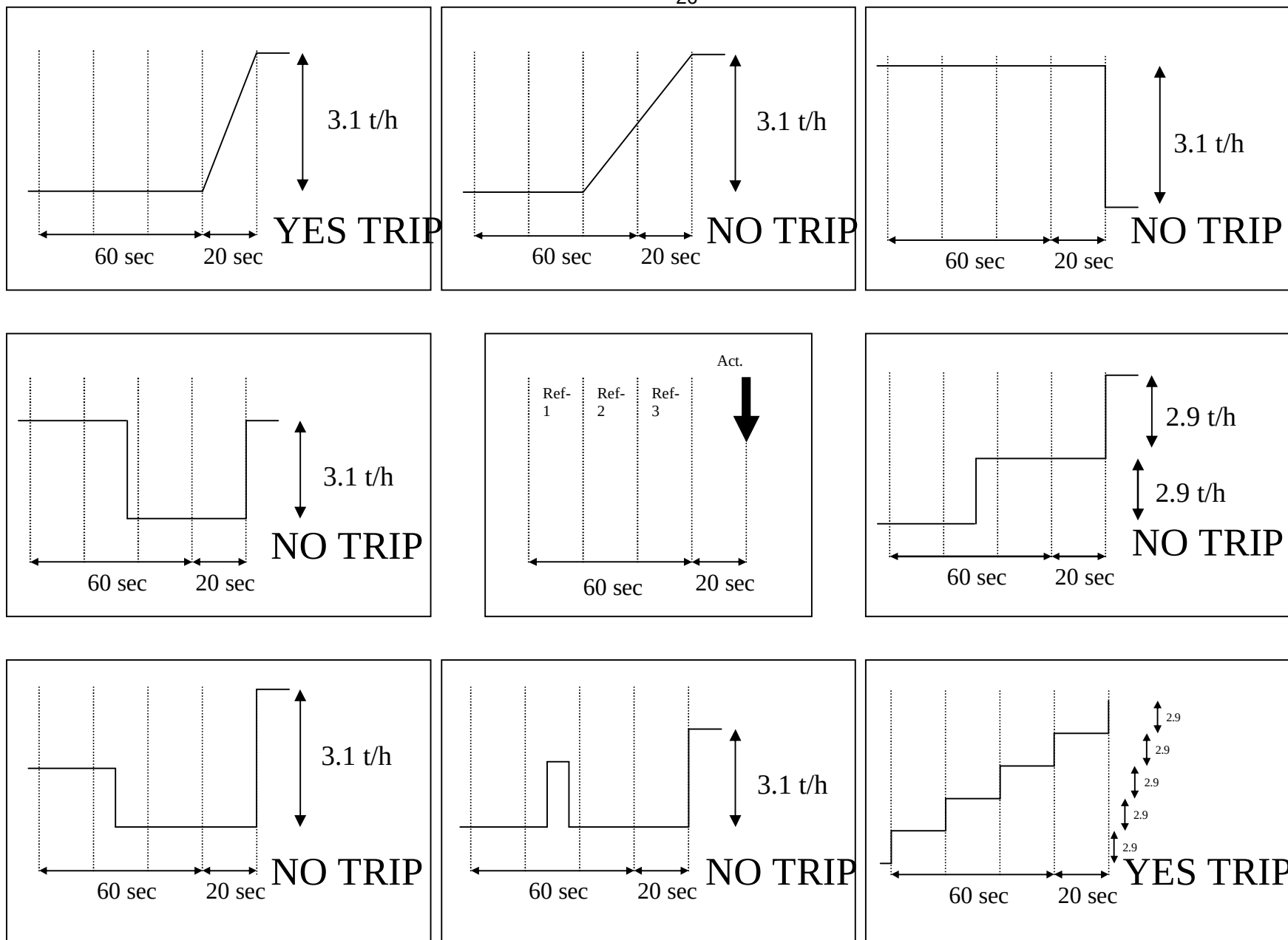


Figure 6: Examples trips and non-trips for oxygen rate of change logic

