



Exploration & Production

GENERAL SPECIFICATION

Field Operation

GS EP EXP 137

OCWR specification

00	05/2008	First Issue
Rev.	Date	Notes



Contents

1. Scope	3
1.1 Purpose	3
1.2 Application	3
2. Reference documents	3
3. Glossary	4
3.1 Abbreviations	4
3.2 Terminology	5
4. OCWR objectives & development principles	6
4.1 Objectives	6
4.2 Development principles	7
4.3 Strategies	8
5. OCWR specification	9
5.1 Production Well Control Module (PWCM)	9
5.2 Production Riser Control Module (PRCM)	14
5.3 Production Overall Control Module (POCM)	17
5.4 Loop Preservation Control Module (LPCM)	20
5.5 Water Injection Well Control module (WIWCM)	22
5.6 Water Injection Overall Control Module (WIOCM)	24
5.7 Gas Injection Well Control Module (GIWCM)	26
6. OCWR integration into the ICSS	28
6.1 OCWR software development	28
6.2 Integration	29
6.3 Human Machine Interface (HMI)	29



1. Scope

1.1 Purpose

This specification describes the minimum requirements for an Overall Control of Wells and Risers (OCWR) system. OCWR is a generic term which covers a set of control algorithms implemented in the Process Control System (PCS) to assist the operator in the control and production of complex subsea systems.

This specification has to be considered in conjunction with project documents which describe the subsea and topside systems, the Operating philosophy for the field, and the extent of automatic sets to be developed for the operation of a subsea system. These documents shall provide additional inputs to this specification to supplement it by a detailed specification which describes all the functional requirements, operating logics and constraints which are specific of a given subsea field.

1.2 Application

This document describes the minimum functionalities of an OCWR system.

This specification only covers subsea production systems which are designed as production loops.

This specification does not cover the case where subsea production wells produce into subsea processing modules (separator, multiphase pump...).

Methanol is considered as the hydrate inhibitor. The use of glycol or low dosage hydrate inhibitor is not developed in this document.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
Not applicable	

Professional Documents

Reference	Title
Not applicable	



Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS EP INS 134	Design and supply of integrated control and safety systems
GS EP INS 150	Design method for system configuration - Standard Functions
GS EP INS 198	Safety and Fire & Gas Standard Functions

3. Glossary

For the purpose of this document, the following terms and definitions apply:

3.1 Abbreviations

AMV	Annulus Master Valve
CCR	Central Control Room
CIV	Chemical Injection Valves
DHP	Down Hole Pressure
DHSV	Down Hole Safety Valve
ESD	Emergency Shutdown
GIWCM	Gas Injection Well Control Module
GL	Gas-Lift
HMI	Human Machine Interface
ICSS	Integrated Control and Safety System
IMV	Injection Master Valve

IWV	Injection Wing Valve
LPCM	Loop Preservation Control Module
MeOH	Methanol
MLV	Manifold Loop Valve
OCWR	Overall Control of Wells and Risers
PCS	Process Control System
PLFR	Production Liquid Flow Rate
PSS	Process Shutdown System
PMV	Production Master Valve
POCM	Production Overall Control Module
PRCM	Production Riser Control Module
PWCM	Production Well Control Module
PWV	Production Wing Valve (Control and Safety)
RBP	Riser bottom pressure
RCHK	Riser head Choke valve(s)
SCU	Subsea Control Unit
SD	Shutdown
SDV	Shutdown Valve
SLD	Safety Logic Diagram
WCHK	Well Choke valve
WHP	Well Head Pressure
WIOCM	Water Injection Overall Control Module
WIWCM	Water Injection Well Control Module

3.2 Terminology

Branch: generic term which describes a set consisting in one riser, its allocated wells and the associated flow lines.

Gas-Lifted (riser): a riser in which Gas-Lift (GL) is injected at riser base, for start-up, activation or stabilization purpose.

Gassing: massive GL injection at riser base with Riser head Choke valve(s) (RCHK) closed to pressurize it.

Kick off: following to “gassing” operation; RCHK is quite opened and GL injection is maintained in order to unload the riser of its liquid content prior to the ramp-up step.

Load shedding: OCWR strategy which consists in a succession of risers and/or wells closure according to a predefined order to prevent a topside safety trip in case of topside capacities saturation.



Module: part of the OCWR system implemented into the PCS. A module manages a dedicated field element (production well, production riser, water injection well, production loop for preservation sequences...).

Natural (riser): non Gas-Lifted riser is defined as “natural”.

Parameter: element which has to be programmed and initialized in automate, mainly by an operator or an engineer (depends of level access).

Preservation: set of operations to be performed on subsea systems (production well, flow line and riser) to prevent hydrate risk for planned and unplanned shutdown (SD) scenario.

Process limitation: specific process constraints on topside systems which can lead to a safety trip.

Severe slugging: periodic multiphase flow phenomenon with accumulation of liquid at riser base which results in large fluctuations of pressure, and liquid and gas feed to the topside facilities.

Strategy: predefined operating logic which reflects the systems constraints and specificities.

Tracking: OCWR control module operating phase where OCWR commands are realigned with safety status.

4. OCWR objectives & development principles

4.1 Objectives

OCWR is a tool whose main objectives shall be:

- To support Central Control Room (CCR) operations for complex subsea production and injection networks, and to reduce the overall workload of the CCR operators.
- To improve subsea production operations in terms of reliability and efficiency by performing systematic and recurrent actions which take into account the specificities and constraints of a given field and subsea infrastructure.

The main OCWR objectives shall be as follows:

For production operations:

- To help to sustain a maximum regular production rate to the topside during steady state conditions and during transient operations such as flow increases and decreases, by:
 - Limiting flow instabilities as far as possible.
 - Preserving the near well bore area by preventing significant pressure variations.
 - Protecting subsea equipments against excessive wear.
 - Avoiding hydrate formation during wells start-up and preservation stages.
- To assist the operator in the management of flow assurance issues.
- To facilitate more efficient loop and field start-ups by assisting the operator via automatic management of key tasks.

- To help to minimise the frequency of topside installations trip, thanks to preventive corrective actions (load shedding).

For gas and water injection operations:

- To maintain an injection rate target for each well, while :
 - Taking topside facilities availability into account.
 - Preserving the near well bore area.
 - Protecting subsea equipments.
 -
- To help to minimise the frequency of topside installations trip, thanks to preventive corrective actions (load shedding).

For preservation operations:

- To facilitate more efficient loop and field preservation by assisting the operator via automatic management of key tasks.

4.2 Development principles

The main OCWR design principles shall be as follows:

- OCWR shall be a set of control algorithms to be implemented in the PCS. It shall systematically reproduce the operations that an operator would execute during manual operations.
- The information gathered by subsea and topside sensors shall enable OCWR to act on relevant actuators through :
 - Predefined established logics, integrating each system's constraints and specificities.
 - Parameters tables, allowing the operator to select options and to improve settings according to practical experience.
- OCWR should not require more sensors or actuators than actually needed for remote operation of subsea systems.
- It shall not have any status in term of performing safety-related functions. In all cases, safety functions shall supersede any OCWR actions. Yet safety logics shall be acknowledged by OCWR to realign the sequence accordingly.
- It shall manage neither subsea valves interlocks nor topside valves interlocks.
- It shall not manage the interlocks for the hydraulic supply to subsea systems.
- It shall be structured into distinct control modules which correspond to the equipments it has to control. In particular, each well and riser shall be controlled by its own control module.
- An overall control module (supervision module) shall monitor topside capacities to allow synchronisation of the actions between wells and risers.
- For specific cases where excessive complexity of subsea systems (methanol (MeOH) network for example) calls for an automation and supervision, specific modules could be developed to prevent undesirable operation of valves or systems.

- For each control module:
 - A set of parameters with a specific access shall allow adapting the OCWR strategies to life of field constraints.
 - A set of commands shall allow the operator to control the corresponding module and to activate selected functions.
- The operator shall be able to deactivate OCWR modules or strategies and to directly perform control actions.

4.3 Strategies

Several strategies are defined into specific project documents: flow assurance strategy, sand management strategy, preservation strategy, production strategy ...

As detailed in § 3.2, for the OCWR point of view a strategy is a predefined operating logic which reflects the systems constraints and specificities.

Several OCWR strategies can be implemented according to projects requirements. Within the most important, production wells start-up strategy and hydrate inhibition strategy at production wells start-up shall be developed whatever the project.

4.3.1 Production wells start-up strategy

OCWR main aim for production loops shall be to manage branches start-up, one by one.

An automatic branch start-up consists in the simultaneous start-up of a riser and of its allocated wells, with respect of each equipment constraints.

When a riser is into its start-up phase, the OCWR shall initiate a wells start-up strategy. This strategy shall:

- Run in parallel with the opening of the RCHK.
- Manage start-up of the required wells (**NOTE**), one by one, according to an order defined into a parameters table.

Branch start-up is considered finished when both the riser and all the required wells have finished their own start-up phase.

Once it is finished, riser and wells are in production phase and they try to reach their functional set point.

When riser is in production, wells start-up strategy shall still be active for wells that are not started yet.

NOTE:

Wells start-up strategy shall give start-up order to wells under OCWR control, that are allocated to this riser and ready to start (please refer to § 5.1.2.2).

4.3.2 Hydrates inhibition strategy at production wells start-up

Hydrate inhibition during production well start-up shall be based on:

- The monitoring of temperatures along the whole branch.
- And the knowledge of production wells water cut.

In case of warm start-up or water free start-up, no methanol injection is required.

Else, the MeOH rate requirement shall be defined as a function of hydrate inhibition strategy.

The MeOH flow rate injected is a combination of the type of valve chosen, or the number of valves to be open, or its opening if adjustable injection valve and the MeOH network pressure vs. well flowing pressure.

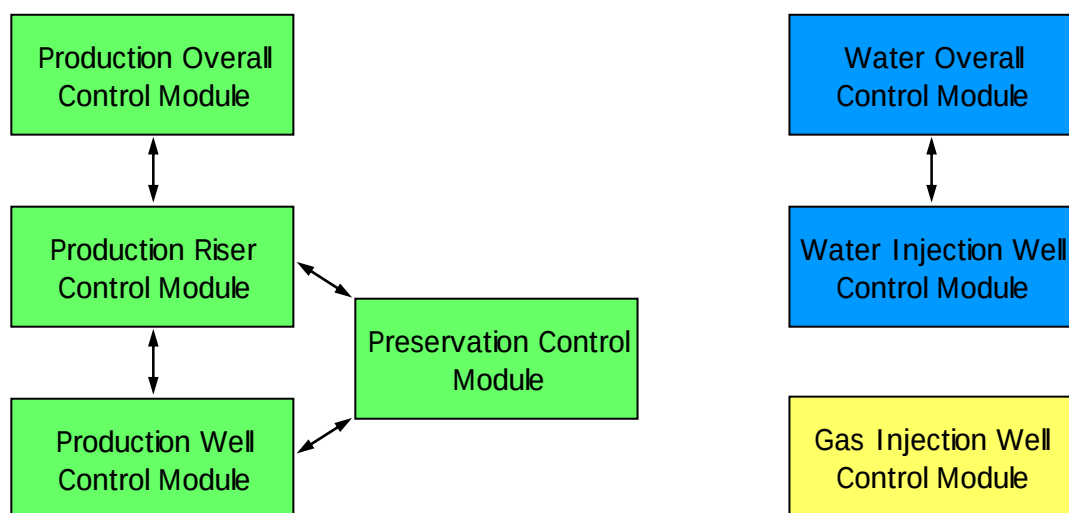
It shall be the operator responsibility to define the flow rate injection set point and the well methanol injection valves (MIV) to be used for production water inhibition at start-up.

OCWR shall neither control nor guarantee MeOH injected quantity.

OCWR shall only manage the opening of the well MIV at start-up and their closure when temperature monitored along the flow path from Xmas tree to topside riser is high enough.

5. OCWR specification

The main OCWR structure shall be as defined in the following diagram:



Arrows represent information exchanges and / or command orders.

NOTES:

- A "Gas Overall control Module" may be developed according to gas injection network complexity and the number of gas injection wells.

5.1 Production Well Control Module (PWCM)

One module shall be developed per production well.

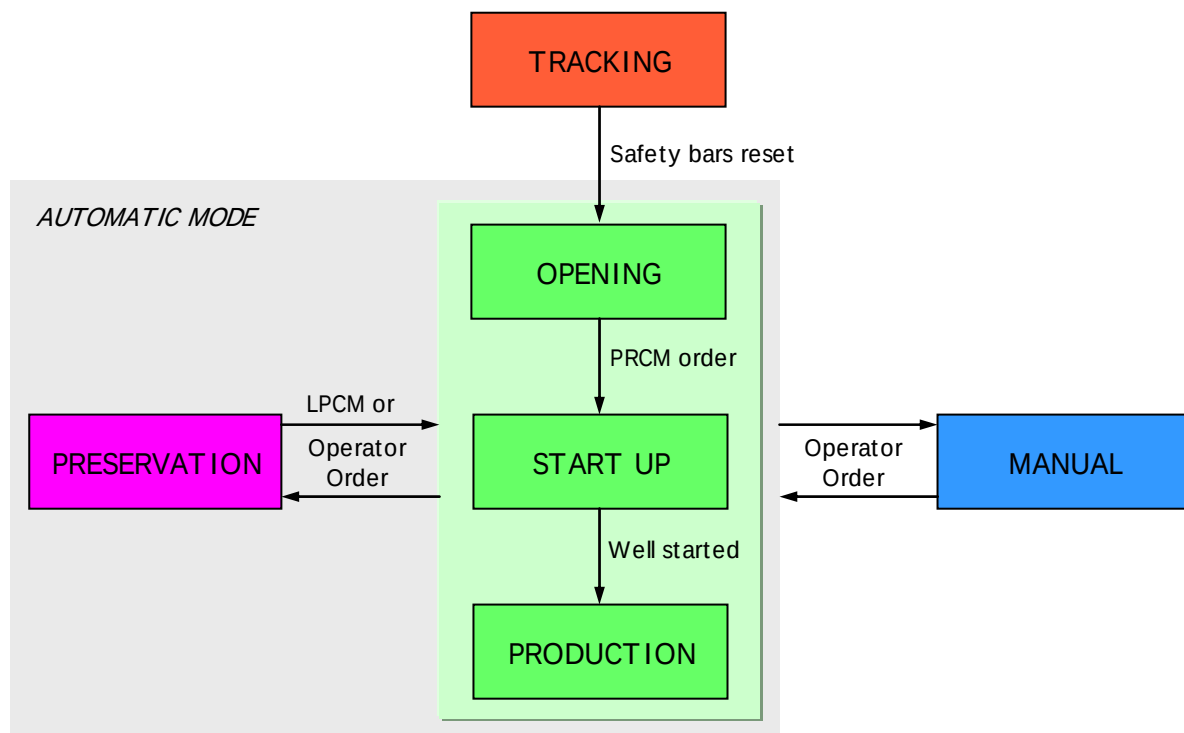
5.1.1 Objectives

The main PWCM objectives shall be:

- To assist the operator in the reopening of well shutdown valves (SDV): Down Hole Safety Valve (DHSV), Production Master Valve (PMV), and Annulus Master Valve (AMV).
- To start the well (opening of Production Wing Valve (PWV)) and ramp-up the well according to predefined criteria for full respect of reservoir, sand control, flow assurance and topside limitations.
- To maintain a predefined production target which accounts for reservoir, flow assurance and topside limitation.
- To reduce the well production if required by subsea network operation constraints (flow restriction, flow assurance constraint, sand management).
- To manage hydrates inhibitor injection into the well, for start-up and preservation.
- To manage chemicals injection into the well.
- To manage closure of individual wells through a dedicated operator "stop" command or in case of preservation.
- To monitor subsea network data and inform the operator with information such as No Touch Time elapsed alarm, in case well has been closed.

5.1.2 Main operating phases description

PWCM shall contain the following operating phases:



- When the well is shutdown, PWCM shall be set in TRACKING mode. All commands to safety valves are overridden by Process Shutdown System (PSS) or Emergency Shutdown (ESD) system. PWCM commands to these valves shall be realigned according

to Safety Logic Diagram (SLD) in order to prevent any conflict. However, calculation and management of other valves shall still be active.

- Choke closure to a “reduced rate” position, if not performed by Subsea Control Unit (SCU), shall be done by PWCM.
- Transition from this phase to OPENING shall be consecutive to the well safety bars reset.
- When not in TRACKING mode or in MANUAL mode, the PWCM shall be in AUTOMATIC mode.

5.1.2.2 Opening

- PWCM shall not open safety valves. It shall send messages to the CCR operator in order to open the required valve.
- OCWR shall assist the following sequence:
 - Opening of PMV (if closed)
 - Opening of AMV (if closed)
 - Opening of DHSV (if closed) after pressure equalization by injection of MeOH, analysis of wellhead pressure and confirmation through pressure trend analysis that the valve is in open position.
 - Opening of only one Manifold Production Valve.
- PWCM shall wait for the operator “ready to start” command (see § 5.1.3, Commands) to specify the end of this phase.
- Transition from this phase to START UP shall be consecutive to a Production Riser Control Module (PRCM) order coming from wells start up strategy.

NOTE:

Subsea Manifold Loop Valves (MLV) configuration for production remains under operator’s responsibility. However, the OCWR shall check the consistency of this configuration to allow each well start-up.

5.1.2.3 Start up

- PWCM shall open PWV after pressure equalization by injection of MeOH, if required.
- Then it shall perform a choke ramp-up up to a predefined production target with or without simultaneous MeOH injection, according to hydrate inhibition strategy requirements.
- Well start-up and ramp-up operations which require methanol injection for hydrate inhibition shall be allowed only if MeOH availability is confirmed (information coming from Production Overall Control Module (POCM), see § 5.3.3.2). In case of loss of availability while injecting, PWCM shall temporarily close the well: PWV closure, MIV closure, WCHK closure to a “reduce rate” position ... Then, the well shall restart upon wells start-up strategy order.
- During the ramp-up phase, PWCM shall continuously monitor Well Head Pressure (WHP) and Down Hole Pressure (DHP) variation for sand control protection purposes. Choke opening shall be adjusted to maintain draw down rate variation within predefined limits.

- During the ramp-up phase, PWCM shall supervise information coming from acoustic sand detector (raw signal information or alarms) and suspend choke ramp-up or close back the well temporarily to a predefined safe position if sand production is confirmed.
- PWCM shall temporary close the well on its PWV under specific defaults (e.g. riser closure, to prevent riser packing). Then, the well shall restart upon wells start-up strategy order (i.e. when the riser is restarting).
- PWCM shall manage Chemical Injection Valves (CIV) opening as defined into the operation philosophy. CIV should be preferably opened at the end of ramp-up when flowing conditions are stable. If required for fluid chemistry purposes, CIV could be opened at well start-up.
- For gas lifted wells, PWCM shall also manage GL injection at well level (GL set point, required valves opening, e.g. Annulus Wing Valve in case of GL injection through the casing ...).
- Transition from this phase to PRODUCTION shall be achieved when some predetermined process conditions are reached (temperature and WCHK opening targets).

5.1.2.4 Production

- PWCM shall act on the choke valve to maintain a predefined production target. This target shall be defined by the well performance engineer as any of the following: WHP, DHP, Production Liquid Flow Rate (PLFR) and choke position.
- The operator shall be able to modify the well production target through dedicated parameters.
- During this phase, PWCM shall continuously monitor WHP and DHP variation. Choke opening shall be adjusted to maintain draw down rate variation within predefined limits.
- PWCM shall choke down the well to a predefined safe position in case of massive modification of flow in the production branches such as severe slugging.
- PWCM shall supervise differential pressure across WCHK to detect back flow conditions and protect the well through generation of alarm to the CCR operator and appropriate actions (WCHK ramp-up pause, WCHK reducing ...).
- If required by the Operating philosophy, PWCM shall monitor subsea sensors and provide the operator with information such as time elapsed since well shutdown, time left for hydrate preservation operation...
- For gas lifted wells, production target could either be:
 - Tubing Head Temperature (THT).
 - PLFR.
 - Dual (temperature for start-up and flow rate for production).
 - Boosting: steady WCHK opening and gas lift flow rate target.

5.1.2.5 Manual

- For each PWCM, a dedicated MANUAL control mode shall allow the operator to deactivate PWCM strategies.

- As long as no safety bar is tripped, it shall be possible for the operator to switch PWCM from AUTOMATIC to MANUAL without disturbing the process.
- In MANUAL mode, all the valves of the well can be operated by the operator if not closed by safety shutdown and not interlocked by the SCU.
- MANUAL mode is to be used during specific operation only and can not be considered as a normal control mode.
- OCWR shall not act on a well in MANUAL mode.
- Switching from MANUAL to AUTOMATIC shall also be possible in some predetermined cases. OCWR shall then check if required conditions are fulfilled to allow the switching, without disturbing the process.

5.1.2.6 Preservation

- PWCM shall manage hydrate inhibitor injection into the well tubing and well jumper through supervision of valve status, operation of valves and injection of predefined hydrate inhibitor volume.
- PWCM shall reproduce in AUTOMATIC mode the hydrate inhibition sequence (e.g. sequence of valve operation, well components to be preserved) as defined in the Operating philosophy and hydrate prevention strategy documents. For that purpose, PWCM shall be able to open and close the PWV and PMV (in order to save time).
- For subsea gas lifted wells, the injection of hydrate inhibitor into the annulus shall also be covered by PWCM logics.
- Loop Preservation Control Module (LPCM) shall activate this stage and manage return to production configuration.

5.1.3 Commands

For the PWCM, the following operator commands shall be developed:

- **Ready to start:** shall be set by the operator to confirm that the OPENING phase has been completed. The well is then waiting for the “start-up” order which comes from a dedicated strategy implemented in the PRCM, see § 5.2.
- **Manu:** PWCM shall be set in MANUAL operating phase described in § 5.1.2.5.
- **Auto:** PWCM shall return in AUTOMATIC according to well equipments status.
- **Stop:** this command shall ensure a well control stop and not a safety one. It shall be set by the operator to close the corresponding well on its PWV.
- **Stop reset:** this command shall permit the operator to reopen the corresponding well. PWCM shall be set in OPENING operating phase described in § 5.1.2.2.

5.2 Production Riser Control Module (PRCM)

One module shall be developed per production riser.

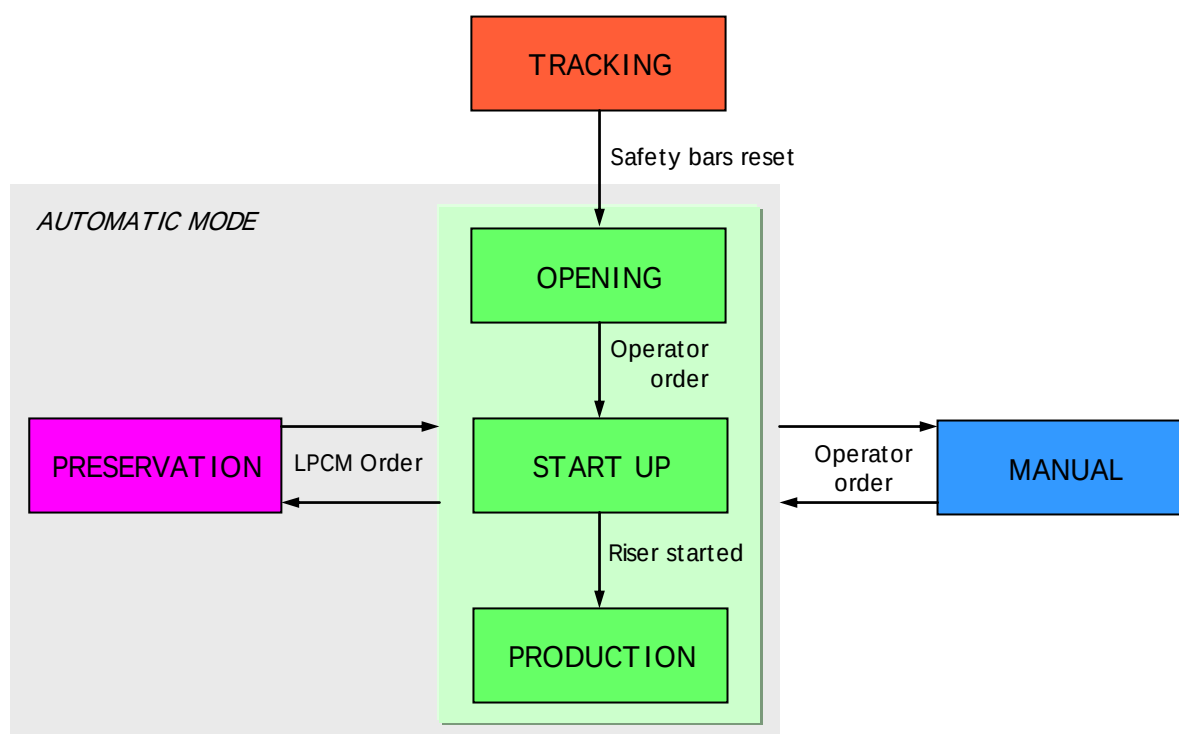
5.2.1 Objectives

The main PRCM objectives shall be:

- To ramp up the riser in a sequence that aims at minimising flow instabilities and surges.
- To manage start-up conditions and start-up in AUTOMATIC mode the wells that flow into the riser controlled by the PRCM, according to a predefined order.
- To maintain a predefined production target per branch.
- To detect the generation of severe slugging and mitigate the impact on topsides and subsea equipment. As a base case the PRCM shall not provide a slug control functionality which would stabilize any flow instability in the riser (from hydrodynamic to severe slugging).
- To contribute to topsides regularity by closing predefined risers and/or wells in AUTOMATIC mode in the event of saturation of topsides processing capacity.
- To manage pig trap valves for preservation stage, if ever relevant SDV can be remotely operated by the PCS.
- To manage and optimise GL injection for risers equipped with riser base GL injection through start-up and / or production phases.

5.2.2 Main operating phases description

PRCM shall contain the following operating phases:



5.2.2.1 Tracking

- PRCM shall not perform any safety actions.
- In case of riser SD or ESD, PRCM shall be set in TRACKING mode, but shall not operate any Emergency Shutdown Valve. All commands to safety valves are overridden by PSS or ESD. PRCM commands to these valves shall be realigned according to SLD in order to prevent any conflict. However, calculation and management of other valves shall still be active.
- RCHK closure, if not performed by PCS / PSS, shall be done by PRCM.
- Transition from this phase to OPENING shall be consecutive to the riser safety bars reset.
- When not in TRACKING mode or in MANUAL mode, the PRCM shall be in AUTOMATIC mode.

5.2.2.2 Opening

- PRCM shall not open safety valves. Because of complexity of riser design, in particular with High Integrity Protection System, that shall be under operator responsibility.
- However, PRCM shall check that valves position is consistent with the opening phase.
- PRCM shall wait for an operator confirmation to determine the end of this phase and set the riser in “start-up” phase.

5.2.2.3 Start-up

- PRCM shall manage start-up of wells set in AUTOMATIC through a dedicated strategy. The strategy shall reflect life of field constraints and well production characteristics (WHP, Flow rate, Gas Oil Ratio, water cut and hydrate inhibition capability). The strategy shall define the sequence of wells to be started on the branch (from first to last). Hence PRCM shall send successive start up orders to associated PWCM according to their start up ranking.
- It shall perform a riser choke ramp-up up to a predefined stabilization target. The stabilization target corresponds to a setting of chokes which has been identified as providing “stable” flow conditions through simulation works or operating experience.
- During this ramp-up, PRCM shall perform severe slugging detection and mitigation actions. The mitigation strategy through riser choke opening and GL rate adjustment shall be activated according to both Riser Bottom Pressure (RBP) variation and riser flow rate monitoring.
- For Gas-Lifted risers, PRCM shall perform a preliminary riser “gassing” and then a “kick off” operation to unload the riser of its liquid content prior to the ramp-up step.
- For Gas-Lifted risers, start-up is allowed only if GL is available. In case of loss of availability while injecting, PRCM shall perform appropriate actions according to riser flow stability (riser closure if not stable, else required riser GL valves closure through a load shedding strategy).
- Transition from this phase to PRODUCTION shall be achieved when riser is stable i.e. when the RCHK has reached its stabilization target and all the associated wells have reached their production targets for a predefined time.

5.2.2.4 Production

- PRCM shall act on the RCHK to maintain a predefined production target. This shall be defined as RCHK opening, Riser Head Pressure (RHP) or RBP.
- The operator shall be able to modify the riser production target through dedicated parameters.
- Severe slugging detection and mitigation shall be active during the production phase.
- For gas-lifted risers:
 - RBP could be defined as a possible production target.
 - The GL injection rate shall be optimized after the start-up phase to meet the production target whilst ensuring flow stability criteria.
 - In case of loss of GL availability, OCWR optimization actions shall be held until GL becomes available again. Specific actions shall be triggered such as closure of predefined risers GL valves through a load shedding strategy (see § 5.3.3.6), to prevent a GL network trip. RCHK opening shall not be reduced.

5.2.2.5 Manual

- For each PRCM, a dedicated MANUAL control mode shall allow the operator to deactivate PRCM strategies. Particularly, wells start up strategy shall be deactivated. However, associated wells that are already producing shall remain in state (both in AUTOMATIC and in MANUAL control).
- As long as no safety bar is tripped, it shall be possible for the operator to switch PRCM from AUTOMATIC to MANUAL without disturbing the process.
- In MANUAL mode, all the valves of the riser can be operated by the operator if not closed by safety shutdown and not interlocked.
- OCWR shall not act on a riser in MANUAL mode.
- There shall not be interaction between riser and wells control mode. Within a same branch, one riser can be in MANUAL and some associated wells in AUTOMATIC, and reverse.
- Switching from MANUAL to AUTOMATIC shall also be possible in some predetermined cases. OCWR shall then check if required conditions are fulfilled (riser valves configuration, topside equipment status ...) to allow the switching, without disturbing the process.

5.2.2.6 Preservation

- PRCM shall reproduce in AUTOMATIC mode the hydrate prevention sequence for the riser as defined in the Operating philosophy and hydrate prevention strategy documents.
- PRCM could be able to operate some specific SDV for pig trap configuration purpose with respect to **GS EP INS 198**.
- It shall handle operations such as :
 - Depressurisation of branches down to a given pressure target.

- Control of pressure rate decrease if ever riser system (e.g. flexible) imposes strict control of depressurisation rate.
- Dead oil circulation operation.
- LPCM shall activate this stage and manage return to production configuration.

5.2.3 Commands

For the PRCM, the following operator commands shall be developed:

- **Start up:** PRCM shall be set in START UP operating phase described in § 5.2.2.3.
- **Manu:** PRCM shall be set in MANUAL operating phase described in § 5.2.2.5.
- **Auto:** PRCM shall return in AUTOMATIC according to riser equipments status.

5.3 Production Overall Control Module (POCM)

There shall only be one module to supervise the whole field production system.

5.3.1 Main Objectives

The main POCM objectives shall be:

- To continuously monitor key indicators of topsides systems identified as being process limitations for the production of subsea network. These indicators shall be used to calculate an availability status of the corresponding systems, such as Oil and gas treatment system (separators), MeOH network, GL network, ...
- To provide PRCM and PWCM with the indication of the status of the systems identified here above.
- To allow or not actions of PRCM and PWCM in AUTOMATIC mode according to the status of these systems (start-up authorization, ramp-up suspension ...).
- To react quickly to avoid topsides overload (level or pressure trips, GL network trip) by performing preventive corrective actions at risers and/or wells level (production or GL load shedding).

NOTES:

1. For cases where MeOH network is considered of high operating complexity, a dedicated MeOH control module could be developed.
2. Water injection system is not monitor by POCM, but by WIOCM (see § 5.6).

5.3.2 Principles

- POCM shall not perform any safety action.
- POCM shall not perform any direct action on topside and subsea equipments. It shall act on PRCM and / or PWCM as a function of topside systems availability and predefined strategies (ranking or priorities).
- MANUAL mode shall not be defined for POCM (because of previous requisite). However, a switch in maintenance access shall be provided to enable or disable this module.



- When the production system is shutdown, POCM shall be set in OFF mode. The POCM algorithms shall be deactivated in order to prevent any conflict with safety actions.
- When not in OFF mode, POCM shall be in AUTOMATIC mode.
- POCM shall not perform any action on production wells and risers which are in TRACKING mode (safety realignment OCWR mode).
- POCM shall not perform any action on wells and risers which are in MANUAL mode (deactivated mode).

5.3.3 Functions

5.3.3.1 Separator system monitoring

POCM shall continuously monitor the following process limitations to define separator system status:

- Level of first stage separator(s) (oil treatment system)
- Pressure of first stage separator(s) (gas treatment system)

POCM shall compare the process limitations values with predefined thresholds (OCWR parameters) in order to define corresponding systems status.

5.3.3.2 Methanol network monitoring

POCM shall continuously monitor the following process limitations to define methanol network status:

- Number of subsea MeOH injection pumps which are started or ready to start.
- Subsea MeOH injection header Pressure.

POCM shall establish MeOH network status thanks to a specific rule and thresholds.

5.3.3.3 Gas-Lift network monitoring

POCM shall continuously monitor the following process limitations to define GL network status:

- GL Network Pressure.
- Number of HP compressors running.
- Gas flow rates.

POCM shall calculate the available GL flow rate thanks to a gas material balance and thresholds.

5.3.3.4 Production actions management

According to production systems status, POCM shall interact with the PRCM and / or PWCM:

- To allow production rate increase, if the topsides availability status proves that processing capacity is available.
- To prevent or suspend production rate increase if processing capacity is limited or close to saturation.

- To decrease production rate and hence prevent safety trip through a predefined load shedding strategy, if processing capacity is saturated:
 - Closure of riser if load shedding of riser has been identified as being the most relevant adjustment of a given field at a given period of field production.
 - Closure of well if load shedding of well has been identified as being the most relevant adjustment of a given field at a given period of field production.
- The load shedding strategy (risers or wells selected for rate decrease) shall be defined and updated through dedicated parameters table.

5.3.3.5 Methanol consumption management

According to MeOH network status, POCM shall allow or not MeOH consumption by PWCM.

If MeOH is available, the POCM shall authorize actions.

In case of loss of availability during automatic MeOH injection, POCM shall not act, but PWCM shall perform required actions.

If this loss occurs at well start-up, the well shall be temporarily closed, then restarted by wells start-up strategy (please refer to § 5.1.2.3.).

If this loss occurs during well preservation no action shall be performed. Indeed, well preservation consists in injecting predefined volumes of methanol. Thus, a loss of methanol during this phase shall not be considered as a major issue. The PWCM shall stay blocked in state until the required volume is reached

POCM shall not manage any priority to restart sequences held because of MeOH unavailability.

POCM shall not calculate if MeOH quantity required is greater than available one.

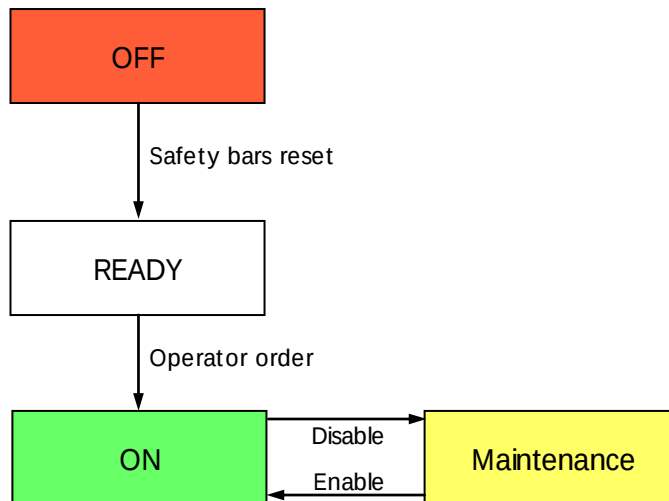
5.3.3.6 GL injection management

According to GL network status, POCM shall interact with the PRCM (and PWCM if production wells need GL):

- To allow GL consumption by PRCM (and PWCM), if the GL network availability status proves that GL network is available;
- To decrease GL consumption and so prevent GL network collapse through a predefined load shedding strategy (successive closures of risers GL valves) if needed.
- The load shedding strategy (risers selected for GL valves closure) shall be defined and updated through dedicated parameters table.

5.3.4 POCM sequence

The POCM sequence shall be as defined in the following diagram:



5.3.4.1 Off

In case of production system SD (SD2), POCM shall be realigned in the OFF state.
When the above safety bar (SD2) is reset, POCM shall be automatically set in READY state.

5.3.4.2 Ready

Monitoring functions are active (see § 5.3.3.1, 5.3.3.2 and 5.3.3.3).
POCM shall be set in ON state upon an operator dedicated command.

5.3.4.3 On

All POCM functions are active.

5.3.5 Commands

For the POCM, the following operator command shall be developed:

- **ON:** POCM shall be set in ON state.

Moreover, the following maintenance switch shall be developed:

- **Enable / Disable:** permit to activate / deactivate POCM strategies in order to prevent any conflict with maintenance operations.

5.4 Loop Preservation Control Module (LPCM)

One Loop Preservation Control Module shall be developed per production loop.



5.4.1 Objectives

The main LPCM objectives shall be to ensure the hydrate preservation of a subsea loop by managing:

- The methanol flushing of all the associated wells & jumpers.
- The depressurisation of both risers of the loop.
- The oil circulation with or without pigging in the whole loop.

5.4.2 Principles

- LPCM shall not perform any safety action.
- The operator shall be able to deactivate (then activate again) individually each LPCM function, if he wants to perform the corresponding task manually.
- At subsea level, LPCM shall only act on subsea MLV to open them prior to dead oil circulation.
- LPCM shall activate PWCM and PRCM PRESERVATION operating phase. Then, it shall only command PWCM and PRCM which are in PRESERVATION.
- LPCM strategies shall launch and synchronize sub sequences implemented in PWCM and PRCM such as:
 - Well preservation. The operator shall be able to launch this operation only.
 - Riser depressurization.
 - Dead oil circulation of subsea loop.
- Finally, when preservation operations are finished, LPCM shall manage PWCM and PRCM return to production configuration.

5.4.3 Functions

5.4.3.1 Wells preservation strategy

A preservation ranking shall be defined for each well of the loop.

It shall be used to define the order of activation of wells PRESERVATION operating phase (see § 5.1.2.6).

Moreover, a dedicated switch per well shall permit the operator to choose to flush or not each well.

5.4.3.2 Risers depressurization

LPCM shall launch the corresponding PRCM sequences which controls the RHP decrease.

5.4.3.3 Oil circulation

LPCM shall monitor the status of subsea valves and open the subsea MLV prior to activating the dedicated PRCM sequences.

During dead oil circulation, LPCM shall act on the flow rate to ramp up dead oil rate at the beginning, and ramp down at the end of the circulation.



During this phase, LPCM shall monitor circulated oil volume.

5.4.4 Commands

The following operator commands shall be developed for each loop:

- **Preservation:** LPCM functions shall be activated. Associated risers shall be set in PRESERVATION operating phase. Wells are set in PRESERVATION by well preservation strategy (see § 5.4.3.1).
- **Production:** LPCM functions shall be deactivated. Associated wells and risers shall return in production configuration.
- **Manu:** each LPCM functions can be deactivated individually. Then, the operator performs the selected preservation task manually.
- **Auto:** selected LPCM function shall return in AUTOMATIC mode.
- **Wells Flushing (Start/End):** to launch / finish wells preservation operation only.

5.5 Water Injection Well Control module (WIWCM)

One module shall be developed per water injection well.

5.5.1 Objectives

The main WIWCM objectives shall be:

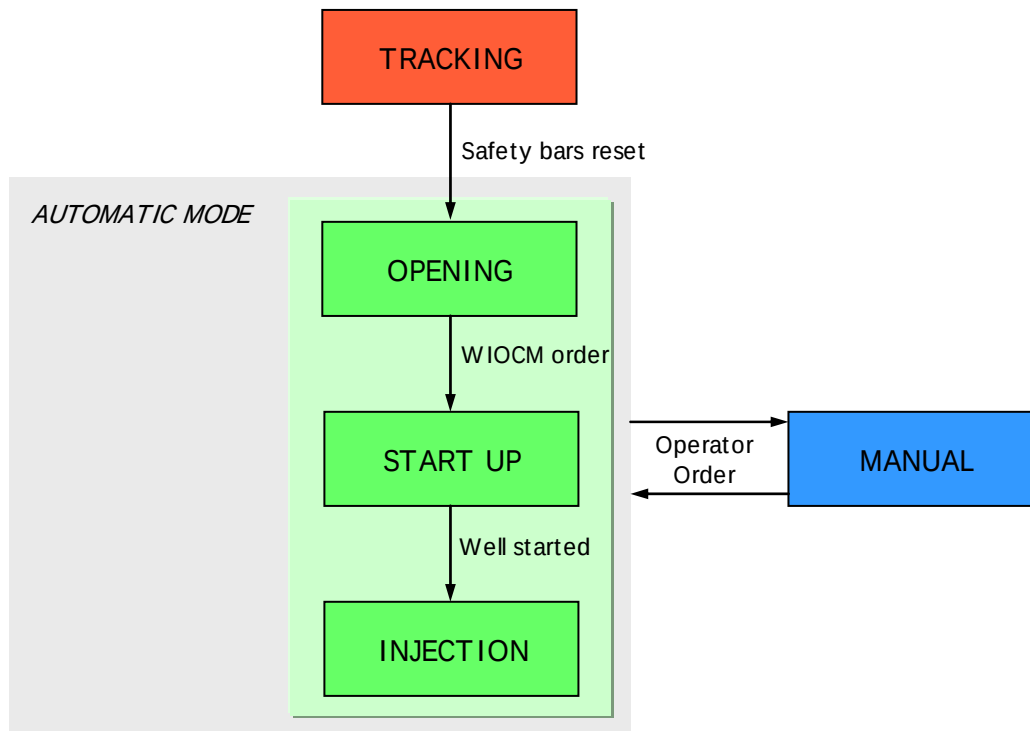
- To assist the operator in the opening of well shutdown valves: Down hole safety valve (DHSV) if any (*see note*), (Injection Master Valve (IMV) and AMV) ensuring that the normal sequence of opening is respected by monitoring sensors and valves status.
- To start (opening of Injection Wing Valve (IWV)) and ramp-up the well according to reservoir and topside limitation.
- To maintain a predefined injection target according to reservoir and topside limitation.
- To reduce the well water injection rate if required.
- To manage closure of individual wells through a dedicated operator “stop” command.

NOTE:

Usually, for water injection, DHSV are flapper valves that naturally open during start-up phase thanks to the injected flow increasing.

5.5.2 Main operating phases description

WIWCM shall contain the following operating phases:



5.5.2.1 Tracking

Same as PWCM, see § 5.1.2.1.

5.5.2.2 Opening

- WIWCM shall not open safety valves. It shall send messages to the CCR operator to assist the sequence and the reopening of valves through analysis of sensors and valve status.
- OCWR shall assist the following sequence:
 - Opening of IMV (if closed)
 - Opening of AMV (if closed)
- WIWCM shall wait for an operator confirmation to determine the end of this phase and set the well as "ready to start" (see § 5.5.3 Commands).
- Transition from this phase to START UP shall be consecutive to a Water Injection Overall Control Module order (WIOCM, see § 5.6) coming from wells start up strategy.



5.5.2.3 Start-up

- WIWCM shall open IWV.
- Then, it shall perform a choke ramp-up up to a predefined injection target. When this target is reached, WIWCM shall move to INJECTION stage.
- If a DHSV is used then, it shall ramp-up the choke to a minimum opening. When this target will be reached, operator shall open the DHSV and WIWCM shall then move to INJECTION stage.
- During this ramp-up WIWCM shall continuously monitor well pressures variation for sand control protection purpose, then act on choke opening accordingly to maintain the variation within predefined limits.
- In case of loss of water availability, WIWCM shall suspend the choke opening ramp up.

5.5.2.4 Injection

- WIWCM shall act on the choke valve to maintain a predefined target among fixed WCHK, WHP, DHP or injection Flow Rate.
- The operator shall be able to modify the well injection target through dedicated parameters.
- Sand control protection shall still be ensured during this phase through monitoring of WHP and DHP variations, and actions on choke.
- In case of critical water injection system status defined by the WIOCM (see § 5.6), WIWCM shall reduce the choke opening through a predefined load shedding strategy, in order to prevent a safety trip.

5.5.2.5 Manual

Same as PWCM, see § 5.1.2.5.

5.5.3 Commands

Same as PWCM (see § 5.1.3), except that the well ready to start is waiting for a “start-up” order which comes from a dedicated strategy implemented in the WIOCM, see § 5.6.3.3.

5.6 Water Injection Overall Control Module (WIOCM)

There shall only be one WIOCM for the whole field.

5.6.1 Objectives

The main WIOCM objectives shall be:

- To continuously monitor key indicators of water injection system identified as being process limitations. The indicators shall be used to calculate an availability status of water injection system.
- To allow or not actions of WIWCM in AUTOMATIC mode according to this status (start-up authorization, ramp-up suspension ...).
- To react quickly to avoid injection system safety trips by performing preventive corrective actions at wells level (water injection load shedding).

5.6.2 Principles

- WIOCM shall not perform any safety action.
- WIOCM shall not perform any direct action on topside and subsea equipments. It shall act on WIWCM as a function of water injection system availability and predefined strategies (ranking or priorities).
- MANUAL mode shall not be defined for WIOCM (because of previous requisite). However, a switch in maintenance access shall be provided to enable or disable this module.
- When the injection system is shutdown, WIOCM shall be set to OFF mode. The WIOCM algorithms shall then be deactivated in order to prevent any conflict with safety actions.
- When not in OFF mode, WIOCM shall be in AUTOMATIC mode.
- WIOCM shall not perform any action on water injection wells which are in TRACKING mode (safety realignment OCWR mode)
- WIOCM shall not perform any action on water injection wells which are in MANUAL mode (deactivated mode).

5.6.3 Functions

5.6.3.1 Monitoring

WIOCM shall continuously monitor the most relevant process limitations to define water injection network status. These process limitations can be:

- Water injection pumps suction pressure.
- Water injection line pressure for each injection line to subsea wells.
- Water injection pumps status.
- Water injection pumps flow controllers output.

5.6.3.2 Water injection management

According to water injection system status, WIOCM shall interact with the WIWCM:

- To allow water injection rate increase (execute a start-up strategy), if the water injection system availability status proves that processing capacity is available.
- To prevent or suspend water injection rate increase (stop the start-up strategy and suspend wells choke opening ramp-up), if processing capacity is limited or close to saturation.
- To decrease water injection rate and hence prevent safety trip through a predefined load shedding strategy, if processing capacity is saturated.

5.6.3.3 Water injection wells start-up strategy

- WIOCM shall execute the water injection wells start-up strategy if the water injection system availability status proves that processing capacity is available.
- Wells shall be started according to a predefined ranking.
- The start-up strategy shall be defined and updated through dedicated parameters table.



5.6.3.4 Load shedding strategy

- WIOCM shall execute the load shedding strategy to decrease water injection flow rate.
- The load shedding strategy shall reduce choke opening of predefined water injection wells.
- The load shedding strategy shall be defined and updated through dedicated parameters table.

5.6.4 Sequence

Same as for POCM, see § 5.3.4.

5.6.5 Commands

Same as for POCM, see § 5.3.5.

5.7 Gas Injection Well Control Module (GIWCM)

One module shall be developed per gas injection well.

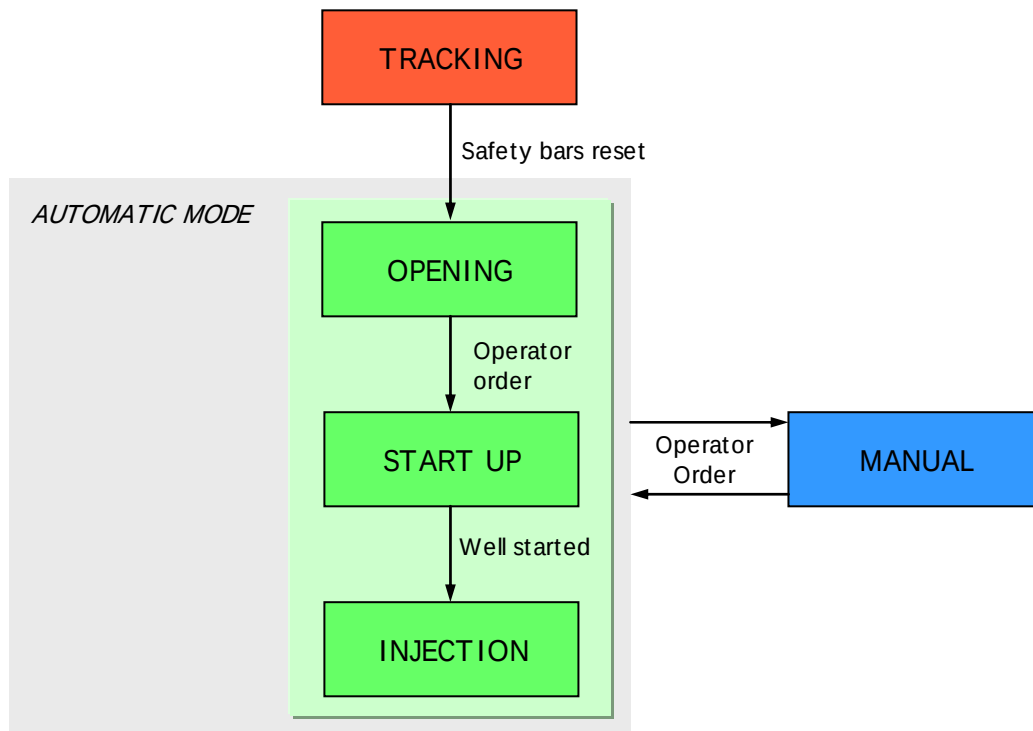
5.7.1 Objectives

The main GIWCM objectives shall be:

- To assist the operator in the opening of well shutdown valves: (DHSV, IMV and AMV) ensuring that the normal sequence of opening is respected by monitoring sensors and valves status.
- To start (opening of IWV) and ramp-up the well according to reservoir and topside limitation.
- To maintain a predefined injection target according to reservoir and topside limitation.
- To reduce the well gas injection rate if required.
- To manage closure of individual wells through a dedicated operator “stop” command.

5.7.2 Main operating phases description

GIWCM shall contain the following operating phases:



5.7.2.1 Tracking

Same as PWCM, see § 5.1.2.1.

5.7.2.2 Opening

- GIWCM shall not open safety valves. It shall send messages to the CCR operator in order to open the required valve.
- OCWR shall assist the following sequence:
 - Opening of IMV (if closed)
 - Opening of AMV (if closed)
- GIWCM shall wait for an operator confirmation to determine the end of this phase and set the well in “start up” phase.

5.7.2.3 Start-up

- GIWCM shall open IWV.
- Then it shall perform a choke ramp-up to a minimum opening. When this target will be reached, operator shall open the DHSV and WIWCM shall then move to INJECTION stage.
- During this ramp-up, GIWCM shall continuously monitor well pressures variation for sand control protection purpose, and act on choke opening accordingly to maintain the variation within predefined limits.

5.7.2.4 Injection

- GIWCM shall act on the choke valve to maintain a predefined target among fixed WCHK, WHP, DHP or injection Flow Rate.
- The operator shall be able to modify the well injection target through dedicated parameters.
- Sand control protection shall still be ensured during this phase through monitoring of WHP and DHP variations, and actions on choke.

5.7.2.5 Manual

Same as PWCM, see § 5.1.2.5.

5.7.3 Commands

For the GIWCM, the following operator commands shall be developed:

- **Start:** GIWCM shall be set in START UP operating phase described in § 5.7.2.3.
- **Manu:** GIWCM shall be set in MANUAL operating phase described in § 5.7.2.5.
- **Auto:** GIWCM shall return in AUTOMATIC according to well equipments status.
- **Stop:** this command shall ensure a well control stop and not a safety one. It shall be set by the operator to close the corresponding well on its IWV.
- **Stop reset:** this command shall permit the operator to reopen the corresponding well.

GIWCM shall be set in OPENING operating phase described in § 5.7.2.2.

6. OCWR integration into the ICSS

6.1 OCWR software development

OCWR functions shall be considered as part of the whole Project application and therefore included into the Project Functional Design Specification (FDS) as per the Appendix 4 of the **GS EP INS 134**.

The OCWR software shall be configured as per the Project Standard Functions described in the **GS EP INS 150** and the associated detailed GS.



6.2 Integration

The OCWR algorithms implementation and distribution into the PCS shall be studied carefully to take into account the following issues, but not limited to:

- Data exchanges optimization between the different OCWR functions (e.g. PWCM and PRCM), with the subsea control system and the other parts of the topsides application.
- PCS controller limitations (e.g. memory size, exchanges capacity...).
- Overall performance including subsea control system, especially total response time.
- Common mode failure.
- Potential known future extensions.

6.3 Human Machine Interface (HMI)

The displays shall be developed according to the Project HMI rules (e.g. animation rules, graphic features...), based on the Appendix 6 of the [GS EP INS 134](#).

Provision shall be made to implement for each well and riser control module the following requirements:

- Dedicated OCWR control window implemented in each well and riser module display, including commands pop-up.
- One or several parameters displays.
- One or several help displays.

Additional displays, not specified in this specification, shall be provided for others control modules (LPCM, POCM, and WIOCM).

6.3.1 OCWR control window

- An OCWR control window shall be implemented within each well and riser process display. This window shall be the main OCWR element to monitor and control the associated equipment.
- As a minimum, it shall include:
 - OCWR module states and sub states;
 - Current timers (tag and remaining time);
 - Facilities to call up commands pop-up, and parameters and help displays;

6.3.2 Parameters displays

- Parameters displays shall be structured according to logical access rights in order to make the operator supervision easier.
- Two kinds of parameters shall be defined:
 - Operating parameters which are linked to the process control and can be modified by the operators;

- And advanced parameters which are linked to the geometry of the installation and the process strategy. Method or Engineer access right is needed to modify advanced parameters.

OCWR parameters shall be used to allow field production control and strategies optimization.

Several kinds of parameters shall be configured:

- Targets (production or injection targets).
- Timers.
- Thresholds (e.g. alarms, process limitation).
- Coefficients (e.g. safety margin).
- Ranking as per operations strategy (e.g. first well to be started, branch to be adjusted or shut to avoid process overload ...).

The parameters access levels shall be as per the **GS EP INS 150**, i.e.

- Visitor: no accessible command.
- Operator: normal process control.
- Maintenance: first level of intervention.
- Method: process parameters modifications.
- Engineer: all system modifications.

OCWR parameters	Logical access rights				
	Visitor	Operator	Maintenance	Method	Engineer
Targets		*	*	*	*
Timers				*	*
Thresholds				*	*
Coefficients				*	*
Ranking				*	*

6.3.3 Help displays

Help displays shall provide the operator with:

- Actions in progress.
- And remaining actions to complete the current phase.