

GENERAL SPECIFICATION

Field operations

GS EP EXP 135

Full Control of Wells (FCW) specification
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01	10/2012	Update
00	03/2008	Original Issue
Rev.	Date	Purpose of the revision

Owning entity: OPS/EXP	Managing entity: OPS/EXP
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1. Scope

1.1 Definition

FCW is a set of control algorithms implemented in the PCS part of the ICSS. Refer to [GS EP INS 134](#).

It aims at reproducing in a sequential, systematic and ideal way the well control operation.

It ensures the transition of the well from a closed state to a stable production state, in which it makes it possible to continuously ensure an optimal oil flow rate, while taking into account the reservoir constraints, the installation's capacities or the well's reactivity.

The data issued from various sensors are treated by **FCW**, which acts on different actuators according to preset parameters.

FCW is a control tool; because of that, and according to [GS EP SAF 261](#), it does not interfere with safety logics. Moreover it will be 'realigned' according to the different safety trip levels.

FCW exists for different types of well and for different means of activation: **naturally flowing, gas-lifted, ESP, PCP**. Several control algorithms are also adapted to gas injection and water injection.

1.2 Purpose of this General Specification

To provide a generic document introducing the **FCW** general and technical descriptions in all its allowed forms and to allow for each **FCW** project:

- The drafting of the **FCW** scope of work, specific to each project, in order to realize the functional analysis that will be given to the integrator.
- The definition of instrumentation and system requirements for the basic engineering.

The chapter « general technical specification » (cf. §3) deals with the implementation measures and principles to take into account in the scope of work.

The chapter "implementation" (cf. §4) deals with the requirements in terms of instrumentation, control system architecture, and the user interface to develop.

1.3 Application

This General Specification, for the **FCW** system implementation, is applicable to new developments and also to sites that are already producing. In either case, the purpose of the **FCW** system is to improve the control and the production of the installation.

The **FCW** system can be deployed on sites (offshore or onshore) producing oil, dry gas, or condensate, and whatever the site topology.

FCW can also be installed to optimize injection on several injector wells.

The **OCWR** (Overall Control of Wells and Risers) is the production optimization system for subsea production fields and is covered by the [GS EP EXP 137](#).

This document only describes the more common **FCW** applications. However, variants can be implemented to satisfy specific requirements of a given site.

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2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
Not applicable	

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP EXP 131	Design and installation of Process Data Server
GS EP EXP 137	OCWR specifications
GS EP INS 134	Design and supply of integrated control and safety system
GS EP INS 197	Process Standard Functions
GS EP SAF 226	Completed wells safety systems and safety rules
GS EP SAF 261	Emergency Shutdown and Emergency De-Pressurisation (ESD & EDP)

2.1 Abréviations

AHFR	Annulus Head Flow Rate (ESP)
AHP	Annulus Head Pressure
AMV	Annulus Master Valve
APCV	Annulus Pressure Control Valve (ESP)
BRS	Back Rotor Spinning (ESP)
BSW	Basic Sediment and Water
CCR	Central Control Room
CPU	Central Processing Unit
CTBP	Coiled Tubing Bottom Pressure
CTHP	Coiled Tubing Head Pressure
DCS	Distributed Control System
DHP	Down Hole Pressure
DHSV	Down Hole Safety Valve
DHT	Down Hole Temperature

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ESD	Emergency Shut Down System
ESD-0	Total Black Shut Down
ESD-1	Fire & Gas Emergency Shut Down
ESDV	Emergency Shut Down Valve
ESP	Electrical Submersible Pump (activation)
FCW	Full Control Of Wells
FGS	Fire and Gas System
FLP	Flow Line Pressure (downstream of production choke)
GL	Gas-Lift
GLFCV	Gas-Lift Flow Control Valve
GLFR	Gas-Lift Flow Rate (PID loop controller)
GLP	Gas-Lift Pressure (header)
GLR	Gas Liquid Ratio = Gas production / Oil + Water production
GLT	Gas-Lift Temperature (header)
GOR	Gas Oil Ratio = Gas production / Oil production
GTS	Gathering & Testing Station
HIPPS	High Integrity Pressure Protection System
HMI	Human Machine Interface
ICSS	Integrated Control and Safety System
PI	Productivity Index
IT	Intensity Transmitter (of a VSD)
MFM	Multi Flow Meter
MTTR	Mean Time To Repair
PCS	Process Control System
PDMS	Process Data Management System
PCP	Progressive Cavity Pump
PID	Proportional, Integral, Derivative
PSS	Process Safety System
PWV	Production Wing Valve
RCV	Production choke
ROV	Remote Operated Valve
RZT	Choke Position Transmitter
SD	Process ShutDown Shut Down
SD-2	Shut Down level 2
SD-3	Shut Down level 3
SDV	Shut Down Valve
SIL	Safety Integrity Level
SSV or UMV	Surface Safety Valve or Upper Master Valve
ST	Speed transmitter (of a VSD)
THDP	Tubing Head Delta Pressure
THP	Tubing Head Pressure

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THT	Tubing Head Temperature
TPS	Temporary Production Stop (FCW)
VSD	Variable Speed Drive
WHSIP	Wellhead shut-in pressure Shut-In-Pressure

2.2 Terminology

No-flowing well: Well that does not produce without activation. A well is considered to be "no-flowing" if no liquid or gas flow is observed on the surface after the activation system has been stopped, the tubing head pressure having been restored to atmospheric pressure and the well production having been stabilized beforehand.

Naturally flowing well: Wells that do not satisfy the "No-flowing well" criteria above are classed as "Naturally flowing".

Oil well: Well producing with a **GLR** lower than 500 (vol/vol).

Gas well: Well producing with a **GLR** higher than 500 (vol/vol).

Injection well: Well flowing from surface installations into the reservoir.

Production system: Set of production wells, producing on a same separation train or a same header. In most cases it is a satellite platform, a cluster or a "Gathering station".

Separation system: Liquids treatment in the production separators.

Gas evacuation system: Production gas treatment chain, toward the flare and the injection or export systems.

Gas-lift production system: Set of compressors, gas production wells and treatments ensuring the supply of the gas for GL activation.

Module: Software object implemented into the PCS and based on algorithmic, sequential or continuous functions that ensure the control of a process unit. In case of identical units the module can be duplicated as many times as needed.

Monowell: Module ensuring individual well management according to specific optimisation criteria.

Multiwell: Module ensuring the optimisation of production of a set of Monowells producing toward a same production system, by active monitoring of defined 'Process limitations'.

Multifield: Module ensuring the optimisation of production of a set of Multiwells producing toward a same central process system, by active monitoring of defined 'Process limitations' of the central process system.

Well testing: Module managing the automatic calculation of wells in test.

Monowell parameters: Set of readable and adjustable values that permit to adapt the FCW algorithm to each real well characteristic. These parameters are set points, thresholds, delays, limits...

Short Stop: When the well is stopped, the "short stop" is defined according to time and head temperature criteria. Short stop allows a faster well restart, and the possible use of a faster ramp up.

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Opening up: Control of the On/Off production valves or control of the reopening action of the valves if previously closed by **FCW**.

Process limitation: Specific process constraints on topside systems (separation, gas evacuation or gas-lift production...) which can lead to a safety trip if wells production is not temporary or permanently adjusted accordingly.

Load shedding: Strategy that is defined for Multiwell and Multifield. For Multiwell, it consists in reduction of either the gas lift consumption or reduction of the well production (or both). It is initiated by the Multiwell control module that is permanently monitoring the defined 'process limitations' to avoid a safety trip of the process, and so to minimize the production shortfalls. Two kinds of load shedding actions are identified:

- Partial = reduced production without stopping of wells.
- Total = closing of wells.

For Multifield, it will optimise the production of the field depending on the evolution of defined Process limitations of the central process system.

Different load shedding strategies can be defined.

Strategy table: table of readable and adjustable values (ranks, delays...) which permits to adapt Multiwell start-up and load shedding orders that are sent to the Monowells. Strategy tables are also defined to adapt Multifield start-up and load shedding orders that are sent to the Multiwells.

3. FCW general technical specification

3.1 FCW General Representation

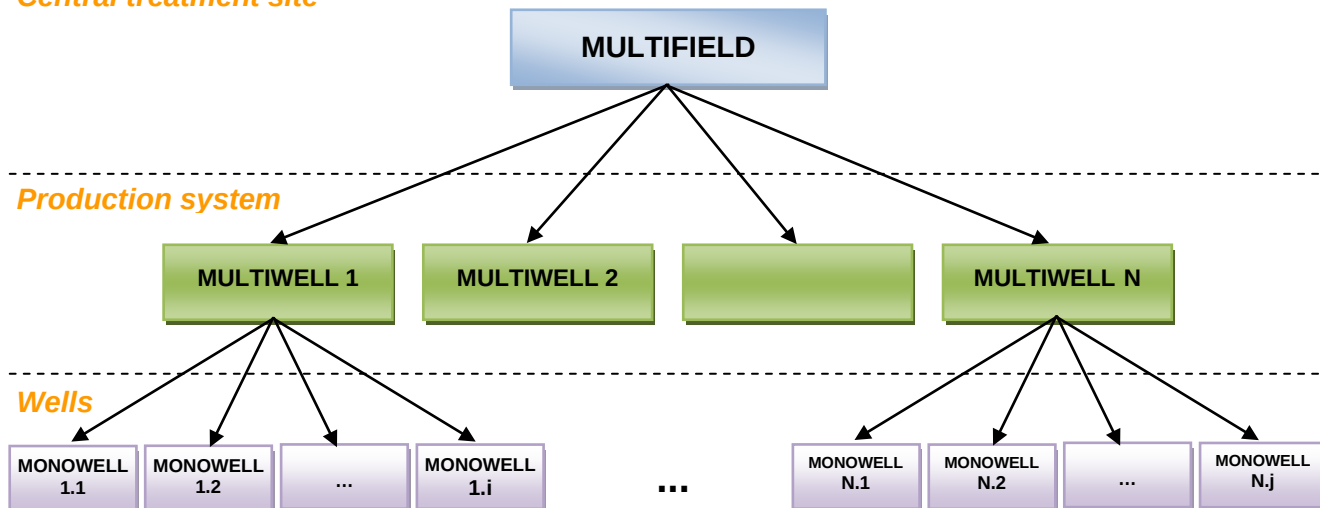
3.1.1 FCW Modules

FCW can have up to three different control levels:

- Monowell.
- Multiwell.
- Multifield.

These modules can be presented as follows:

Central treatment site



3.1.2 Monowell module

- The well is individually managed according to its own optimization criteria. It is independent from the separation / treatment system and of the gas-lift production / distribution system.
- Control valve commands and frequency set points are under **FCW** control. **PID** controllers are used in cascade and the operator cannot access individually to the valve commands or the set points.
- In Monowell control mode, the start-up order for each well is given by the control room operator on the well view. Once the order is given, the start-up stage is an automatic operation.

3.1.3 Multiwell module

- Wells are managed not only according to their own optimization criteria, but also and in priority according to treatment system or gas-lift production process limitations.
- The Multiwell general start-up order is given by the operator. Once given, Multiwell will tend to optimize production according to process status. Therefore, it will refer to the Multiwell start up table to send start up orders to Monowells while respecting ranks and delays as defined in this table.
- The Multiwell control module continuously monitors the process limitations and according to predefined scenario (quick level or pressure increase in a separator or in an export pipe) applies a liquid or gas production reduction strategy. The aim of this action is to prevent safety trips and so to avoid associated production shortfalls.
- For the gas-lifted wells, the Multiwell control module continuously monitors gas-lift availability. In case of a gas-lift network pressure decrease, it applies a consumption reduction strategy leading in priority to the closure of the less productive wells (high

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BSW). The aim of this action is to prevent a destabilization of all the wells requiring gas-lift supply.

- A well that was in Multiwell mode and has been stopped by a production system common stop (**TPS**, **SD-2** or higher) will stay in this mode in order to be restarted automatically.
- For each well, the control room operator has to select a production mode (Monowell or Multiwell). This choice can be done after well restart. Multiwell mode is the recommended mode for an optimization of the production. Monowell mode will be selected on specific occasions, during well test for example as the well must remain at a stabilized production target.

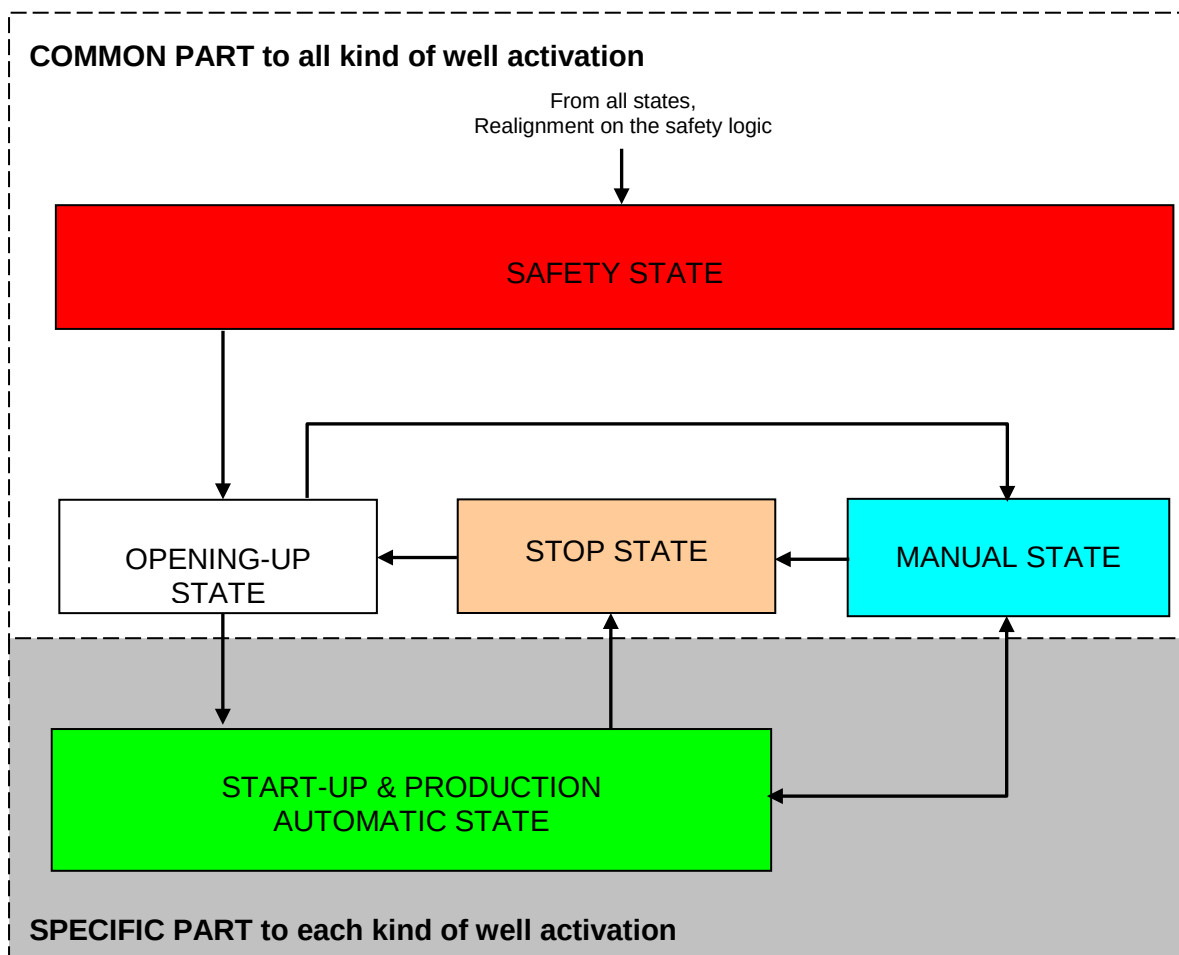
3.1.4 Multifield module

- Multifield control module only acts on wells that are switched in Multiwell control mode.
- Multifield control module manages the central treatment system process limitations, such as water treatment or flared gas...
- The Multifield control module continuously monitors the production and evacuation systems process limitations and according to predefined scenarios (high flaring, saturated water treatment), it applies a strategy to reduce the flow (or close) of selected wells.
- To ensure the uniqueness of the orders sent to the wells, the Multifield control module cannot directly act on the wells, but it does act on the Multiwell control modules required strategies.

3.2 MONOWELL module

Monowell module includes different states that are linked together in a specific sequence.

3.2.1 Wells main control sequences



COMMON PART: states are similar for all kind of well activation.

SPECIFIC PART: states are specific for one kind of well activation.

3.2.2 Common part

3.2.2.1 Safety state

Refer to **GS EP SAF 226** for well safety management:

- Safety logics and the associated safety valves are managed by **ESD**, **PSS** and **FGS** and are **out of FCW**. Safety logics always have priority over **FCW**.
- In accordance with **GS EP SAF 261**, **PWV** and **SDV** are safety valves that may be remotely controlled by **FCW** if fitted with an additional specific solenoid independent from the safety trip circuits. This is to prevent a spurious reopening of these valves upon safety bar reset. In this case, the reopening of **PWV** and **SDV** is automatically managed by the **FCW** when the operator wants to restart the well.

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- **DHSV** and **SSV (or UMV)** safety valve position feedbacks are required by the **FCW** in order to manage the valves opening sequence during start-up.
- For **ESP** and **PCP**, the variable speed drive is equipped with safety shutdown command, managed by the **PSS**, and with a start/stop control command, managed by the **FCW**.

The Safety state is a realignment of the **FCW** sequence in case of safety trip.

When the safety bar of the well is tripped, **FCW** will immediately close control valves (**RCV**, **GLFCV**) and **PWV** and **SDV** (if fitted with a specific additional solenoid).

- Variable speed drives are stopped by the **FCW** using their “stop” control command.

3.2.2.2 Opening-up state

- This state is active after safety bars reset.
- The external operator reopens the **SSV** and - if needed - the **DHSV** at the well control panel.

FCW keeps the control valves closed, the control solenoid valves of the **SDV** and **PWV** closed and the variable speed drive control command on “stop”.

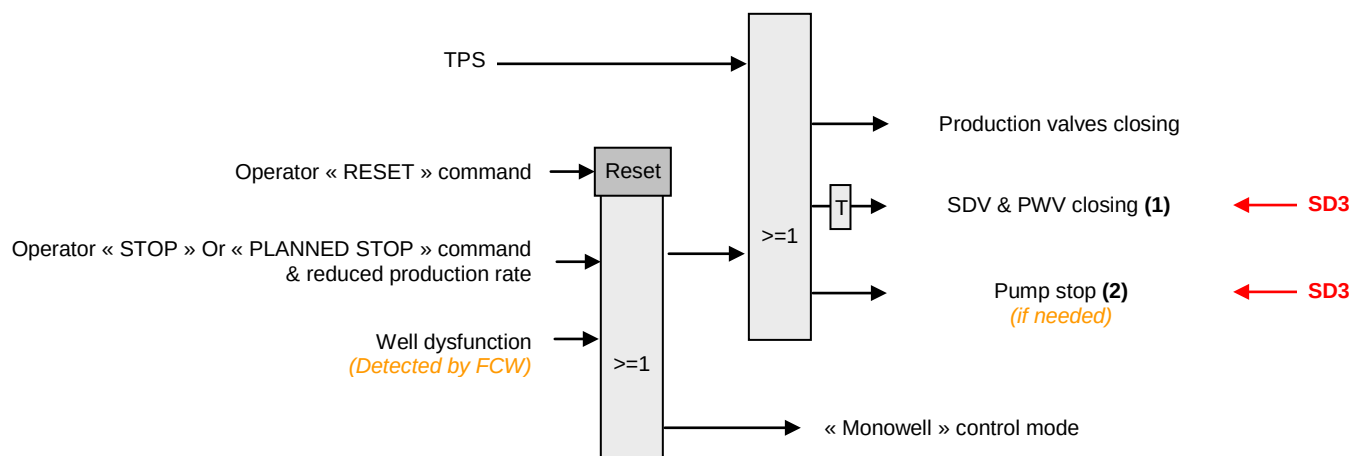
3.2.2.3 Manual state

- In most cases, this state is reserved for special operations (wire line servicing, safety valve leak testing, maintenance, etc...), or in case of dysfunction of the **ICSS** or of the instrumentation.
- As soon as the safety bars have been reset Manual control mode can always be activated by the operator.
- In this mode the operator can access all the control valve commands or all the frequency set points managed by the **FCW**, without any restriction. **PID** controllers can be operated either in **AUTO** or **MANU**.
- Safety logics are still active and they still have priority.
- Well can be switched back by the operator in Monowell control mode when in production state, on condition that valve configuration is consistent with the one required by **FCW** in this state, i.e. Safety valve actuators opened and control valves inside their adjustment ranges.

3.2.2.4 STOP state

- **FCW** includes a control Stop function implemented in the **PCS**. This is not a safety stop. It allows:
 - A smooth stop of the well when it is planned and preceded by a progressive closing of the chokes. This kind of stop is activated by the **Planned Stop** command (see §3.2.4).
 - A “clean and quick” stop of the well either when a well dysfunction is detected or when the operator wants to quickly stop the well. This kind of stop is activated by the **Stop** command (see §3.2.4).
- In both cases, **PWV** and **SDV** are closed last, after a temporization.

- **FCW control STOP** function includes a **RESET** command in order to acknowledge it before start-up.



(1) Specific solenoid for control actions

(2) start/stop control command

3.2.3 Specific part

Start-up and production state:

Start-up state, the well is started by an operator order on the well DCS view that immediately opens the control solenoid valves of the **PWV** and **SDV**, activates the “start” command of the variable speed drive and directly launches the start-up phases.

Start-up sequences are different according to the different kind of activation but they have the same goal: to bring the well from a stop state to a stable (but not already optimized) production state.

Production states are different according to the different kind of activation. The aim of the production state is to reach a stable and optimized production target.

3.2.3.1 Naturally flowing wells specific part

Monowell control algorithm for naturally flowing wells is characterized by:

- A production target that can be estimated by one of the following means: a wellhead pressure, a delta-P measurement on the choke or a wellhead temperature or a bottom delta-P.
- A strict control of pressure variations (head & bottom) for the well bore formation interface and downstream installation protection during start-up and production.
- A slower start-up ramp-up that can last several hours according to the stop duration, the kind of well bore formation interface and the wellhead pressure variation.
- A stop following ramp-down, when programmed (different from the safety cases).

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- The possible regulation of a methanol injection valve upstream of the choke according to the upstream choke temperature in order to prevent hydrate formation.

Multiwell algorithm includes:

- A choke opening pause (of one or several wells) according to selected parameters on the separation/treatment system.

A production load shedding in two stages, partial and total, with a different strategy for the gas network and the oil system.

3.2.3.2 Gas-lifted wells specific part

Monowell algorithm for gas-lifted wells specificities:

- A single modification of well settings permits the algorithms to take into account the evolution of well life (1).
- Two kinds of start-up are possible: **Closed** (production choke is closed during the casing compression phase) and **Opened** (production choke is opened and tubing decompression is performed in parallel with casing compression) (2).
- Production flow rate can be estimated according to the wellhead temperature or the delta-P on the choke or the Down Hole Pressure (**DHP**). Gas-lift flow rate is estimated according to casing pressure gradient.
- Possibility to manage a short stop that allows a quick return to the previous production settings without going through some of the long start-up phases.
- During production stage: continuous optimization of the injected gas over production liquid rate ratio, at the same time maintaining well stability.
- A possible chemical injection valve regulation according to well state.

Multiwell algorithm includes (3):

- The possibility to boost the well by injecting more GL in case of gas-lift excess.
- Gas load shedding in case gas-lift is no more available.

(1) Three kinds of exploitation modes are accessible via the parameters setting:

Naturally flowing (without gas-lift), the well does not need GL - neither to start nor to get a steady maximum production.

Activated (by gas-lift), gas-lift injection is necessary both for start-up and production.

Specific or Unusual Gas Lift, are included in this type:

- Wells that are able to start without assistance (in order to deliver low pressure gas to the compressors) but that need gas-lift for a nominal production.
- Wells that need low casing pressure for start-up and production.
- Semi eruptive wells that need gas-lift injection for start-up but are able to produce without it.

(2) "Closed" start-up allows a high casing compression before start-up. In "opened" start-up, gas-lift injection and well start-up are performed in parallel.