

GENERAL SPECIFICATION

Field Operations

GS EP EXP 135

Production and/or injection optimization system

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1. Scope

This General Specification defines the structure and functions of the Full Control of Wells (FCW) system, used to optimize start-up and/or injection on different types of producing (naturally-flowing, gas-lift, ESP, and PCP) and injecting wells on an oil field.

The objectives of this General Specification are as follows:

- To define the instrumentation and system requirements for basic engineering;
- To assist in drafting precise specifications for the FCW of a project for the Contractor engaged by the Company to program the system.

This General Specification is used by the project group multidisciplinary team, with the support of the Field Operations Discipline, from the pre-project phase until before the end of basic engineering, to choose one or more configurations for the FCW system, depending on the technical production and injection options selected for the oil field. The project team may prepare the data for the specifications using the list in **Appendix 1**.

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

1.1 Definition of Full Control of Wells (FCW)

FCW is a set of control algorithms implemented in the **PCS** part of the **ICSS** (see [GS EP INS 134](#)). It reproduces repetitive, sequential well-control operations by processing data from various sensors. The **FCW** operates and controls the various actuators, according to predefined parameters.

It ensures the transition of the well from a closed state to a stable production (or injection) state, continuously optimizing the production (or injection) rate, while taking into account the reservoir constraints, the installation's capacity, and the well's reactivity.

The **FCW** control system does not interfere with safety logics, in compliance with [GS EP SAF 261](#).

1.2 Field of application

This General Specification is applicable to all projects (greenfield and brownfield) and existing facilities, within the perimeter of assets operated by the Company.

The **FCW** system may be implemented on offshore or onshore sites producing oil, dry gas, or condensates.

2. Reference documents

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

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External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, 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 addendums, is the latest revision published.

Reference	Title
GS EP ELE 261	Solar Power System
GS EP EXP 131	Design and installation of Process Data Server - Creation and administration of Asset Model using Field Share method
GS EP EXP 137	OCWR specification
GS EP INS 134	Design and supply of integrated control and safety system
GS EP SAF 226	Completed wells safety systems and safety rules
GS EP SAF 261	Emergency Shutdown and Emergency Depressurisation (ESD & EDP)
GS EP TEL 170	Communications Network

3. Terminology

The abbreviations are explained in **Appendix 2**.

Load-shedding: Strategy defined for Multiwell and Multifield modules.

Process limitation: Parameters representative of the process operation and monitored by the Multiwell and Multifield modules.

Module: Software object implemented in the PCS, based on algorithmic, sequential, or continuous functions used to control a process unit. A module may be duplicated as many times as needed to run several identical units.

Monowell: Module controlling an individual well according to specific optimization criteria.

Multiwell: Module controlling a set of "Monowell" modules belonging to wells in the same production or injection system.

Multifield: Module controlling a set of modules:

- "Multiwell production" belonging to production systems producing on the same central treatment site, according to the constraints specific to the central treatment system and activation system (gas-lift system, electrical power for ESP).

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- "Multiwell injection" supplied by the same central injection site, according to the constraints specific to this system.

Monowell parameters: This is a set of values for adapting the Monowell algorithm to the actual characteristics of each well.

Gas-lift activation system: A set of compressors, gas wells, and treatment systems to provide activation gas for gas-lift wells.

Gas evacuation system: Treatment system for gas associated with production, transferring it to injection or export systems, or to the flare.

Production system: A set of production wells, producing on the same separation train or manifold. In general, this is a satellite platform (offshore field), cluster, or "gathering station" (onshore field).

Separation system: Liquid treatment in the production separators.

Strategy table: In "Multiwell" control, this table defines the start-up and load-shedding sequences for the "Monowell" units. In "Multifield" control, it defines the start-up and load-shedding sequences for the "Multiwell" units.

4. FCW general technical specifications

Depending on the treatment process, **FCW** may consist of three different control modules, aimed at optimizing start-up or injection on each well:

- Monowell
- Multiwell
- Multifield.

Depending on the complexity of the field and the technical/operating constraints, the project group multidisciplinary team decides to install the "Monowell" level or the "Monowell"/ "Multiwell" or "Monowell"/ "Multiwell"/ "Multifield" levels.

4.1 General overview of FCW

FCW may include up to three different control levels. These modules are arranged as shown in Figure 1.

Central treatment site

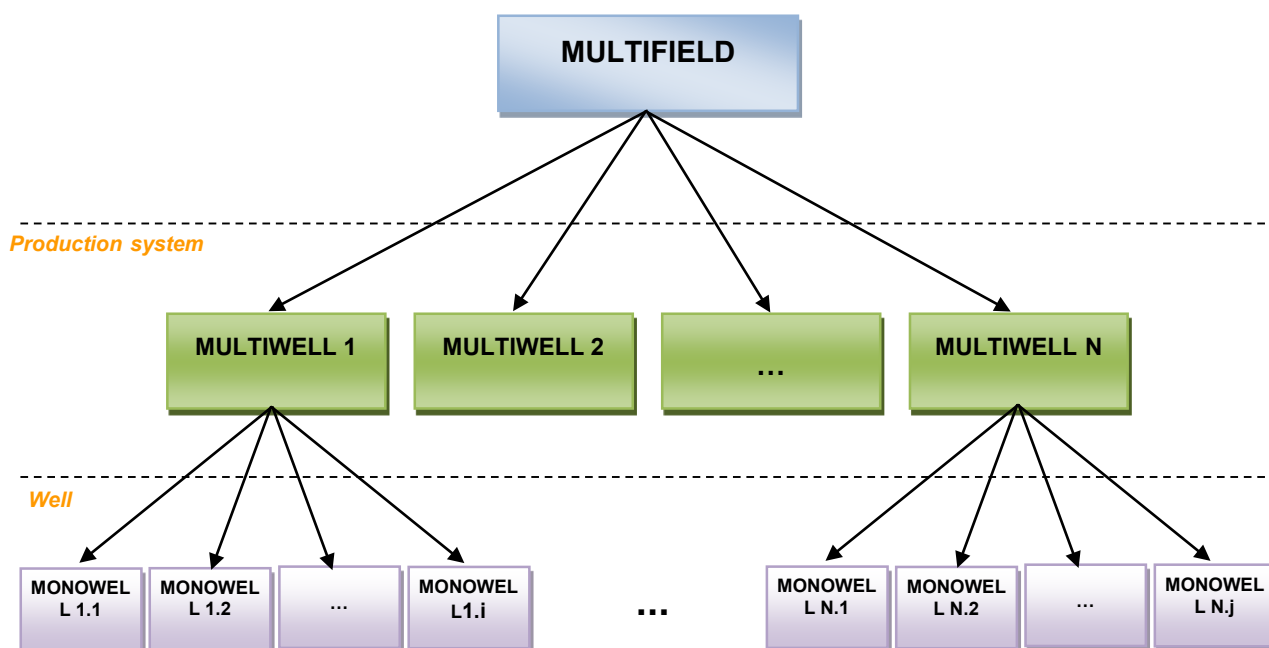


Figure 1: FCW organization

4.1.1 "Monowell" control

A "Monowell" module is allocated to a single well only.

There are several "**Monowell**" modules, to suit different well start-up sequences: naturally-flowing, gas-lift, ESP, PCP, and injector wells.

The "**Monowell**" module manages each well individually, according to its own optimization criteria, independently of the state of the collection/processing (or injection) system and the activation system (if any).

4.1.2 "Multiwell" control

A "**Multiwell**" module is assigned to a cluster (or gathering station) for onshore fields or a well platform for offshore fields.

The aim of "**Multiwell**" is:

- to optimize start-up (or injection) in the cluster (or on the well platform), depending on the behaviour of the process;
- to avoid triggering a safety stop of the process, in order to minimize production/injection shortfalls.

4.1.3 "Multifield" management

A "Multifield" module may be installed in a treatment centre for onshore fields or a central treatment platform for offshore fields.

Similarly to the "Multiwell" module, the aim of the "Multifield" version is:

- To optimize start-up (or injection) in the treatment centre (or central treatment platform) depending on the behaviour of the process;
- To avoid triggering a safety stop of the process, in order to minimize production/injection shortfalls.

4.2 "Monowell" module

{Rule 1:

The "Monowell" module shall include several states linked in a specific sequence, as described in Figure 2.}

COMMON INFORMATION = similar states for all types of well activation.

SPECIFIC INFORMATION = specific states for each type of well activation or injection.

4.2.1 Main well control sequence

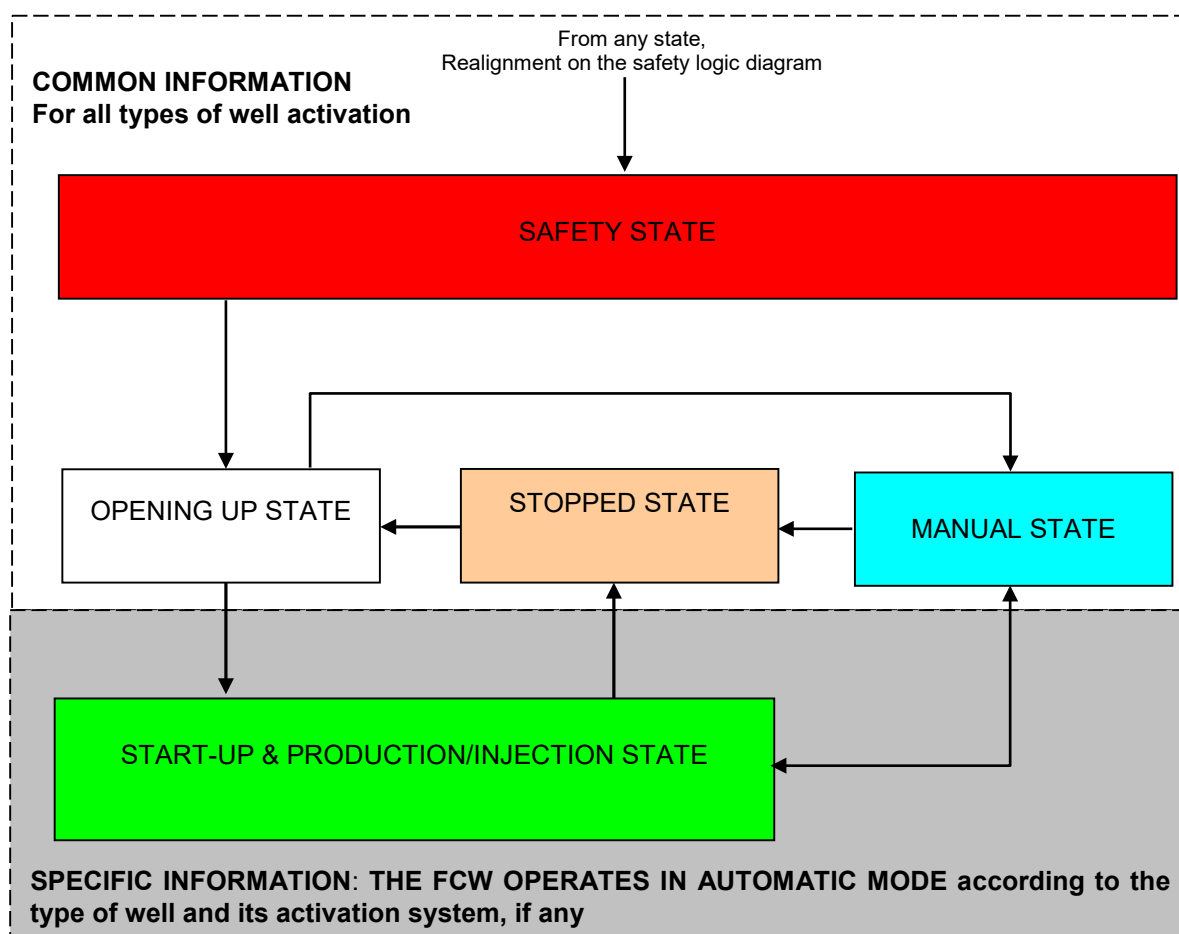


Figure 2: Main well control sequence

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4.2.2 Common information

4.2.2.1 Safety state

Refer to [GS EP SAF 226](#) for well safety management.

{Rule 2:

Safety logics shall be processed in the ESD, PSS, and FGS, and not in FCW. Safety logics always take priority over FCW.}

This requirement is applicable to all three **FCW** modules. In compliance with [GS EP SAF 261](#), the **PWV** and **SDV** (installed on gas-lift injection in annulus A/coiled tubing or the gas ventilation of annulus A) are safety valves that can be remote-controlled by the "**Monowell**" module.

{Rule 3:

The PWV and SDV (if any) shall be equipped with additional solenoids independent of the safety circuits.}

This is to prevent a spurious reopening of these valves when the safety bar is reset. In this case, the reopening of the **PWV** and **SDV** valves is automatically managed by the "**Monowell**" module when the control panel operator restarts the well.

DHSV and SSV (or UMV) safety valve position feedbacks are required by the FCW to manage the valve opening sequence during start-up.

{Rule 4:

In case of ESP and PCP, pumps shall be equipped with a safety stop operated by the PSS and a start/stop control operated by the "Monowell" module.}

When the well safety bar is tripped, the "**Monowell**" module displays the 'Safety' status and implements the following actions:

- The "**Monowell**" module immediately closes the control valves (**RCV** and **GLFCV**), as well as the **PWV** and **SDV** valves (if they are equipped with a specific solenoid);
- The "**Monowell**" module sends a 'stop' signal to any pump(s) in operation.

4.2.2.2 Opening up state

This state is implemented when the safety bars have been reset by the control panel operator.

During this stage, the "**Monowell**" module simply reminds the control panel operator which safety valves to open to restart the well. The "**Monowell**" module checks whether the valves have been reopened (as suggested).

The external control panel operator, in conjunction with the control room, reopens the **SSV** safety valves and the **SCSSV** - if necessary - via the well control panel.

During this stage, the "**Monowell**" module keeps the **PWV** solenoid control valve closed (as well as any **SDV** solenoid valves). The "**Monowell**" module also keeps the control valves closed and the pump stopped (in pump activation mode).

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4.2.2.3 Manual state

In most cases, this state is reserved for special well operations (wireline servicing, safety valve leak testing, maintenance, etc.), or in case of malfunction of the **ICSS** or instrumentation.

Manual control mode can be activated by the control panel operator at any time, as soon as the safety bars have been reset.

In this mode, the control panel operator can access all the control valve commands or frequency set points managed by the "**Monowell**" module, without any restrictions. **PID** control loops may be run automatically or manually.

Safety systems are always active and have priority.

The control panel operator may only return the well to '**Monowell** automatic' mode and directly to the production state, if the well meets the synchronisation conditions: safety valves open, actuators and control valves within the adjustment ranges (and pump, if any, operational).

4.2.2.4 Stop state

The "**Monowell**" module includes a stop function implemented in the PCS. This stop function is totally separated from the safety systems (PSS and ESD).

Depending on the type of production (naturally-flowing, gas-lift, ESP, PCP) or injector wells, the control panel operator has a choice of two types of stops:

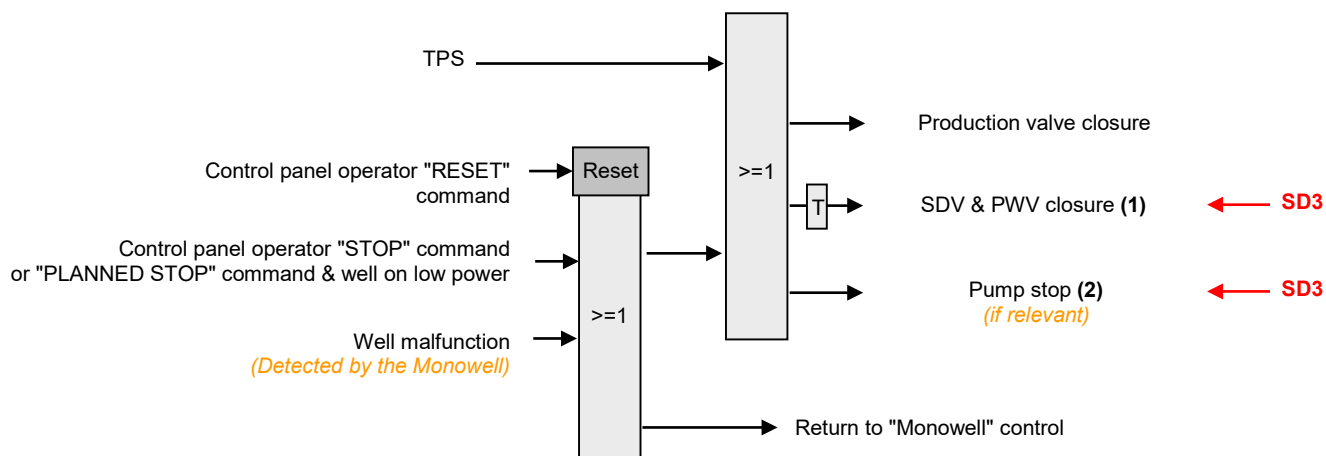
- A "smooth" well stop, when this operation is selected. The "**Monowell**" module gradually closes the well control valves or slows the pump (if any) before stopping the well. This type of stop is activated by the "Planned stop" command. (see section 4.2.4);
- A "clean, quick" stop of the well, either when a well malfunction is detected or when the control panel operator decides to stop the well. This type of stop is activated by the "Stop" command. (see section 4.2.4).

In both cases, **PWV** and **SDV** are closed last, after a time delay.

The FCW-STOP control function includes a RESET command to prepare for a restart.

This FCW-STOP bar may be triggered by certain anomalies, specific to the type of production, detected during well start-up/operations.

If the STOP bar is triggered, it transfers any wells on "Multiwell" operation to "Monowell".



(1) control solenoid, (2) control system start/stop command

The STOP function is adapted to the type of activation: some malfunctions during the start-up sequence may also trigger the STOP bar.

4.2.3 SPECIFIC information

4.2.3.1 Start-up and production/injection state

Start-up state: two types are possible, depending on whether the well is in "Monowell" or "Multiwell" mode.

- In "Monowell" mode: the start-up order is given by the control panel operator;
- In "Multiwell" mode, the start-up order is given by the "Multiwell" module.

Once the order is given, the "**Monowell**" module executes the start-up sequence automatically, applying predefined settings and parameters. It opens the control solenoid valves of the **PWV** and **SDV** (if any), and proceeds directly through the start-up phases (including activation of the start command to the pump(s), in case of pump activation).

Start-up sequence: this varies according to the type of activation, but the objective is always to bring the well from a complete stop to a stable (but not yet optimized) production state.

Production states: vary according to the type of activation, with the objective of reaching a stable, optimized production target.

Injection state: the objective is to bring injection to a stable target value, adapted to the well.

Control valve commands and frequency set points are controlled by the "**Monowell**" module, control loops are used sequentially, and the control panel operator cannot access the individual valve commands or set points.

A detailed table shows the advanced well parameter settings for each well: these readable, adjustable (with specific rights) values are used to adapt the "**Monowell**" algorithm to the actual characteristics of each well. These parameters are: the various types of start-up, targets, set points, thresholds, lag times, and adjustment limits.

4.2.3.2 Specific information for naturally flowing wells

The "Monowell" control algorithm for naturally flowing wells is characterized by:

- A choice of production targets (target selected by the control panel operator for each well): wellhead pressure (**WHP**), estimated production flowrate (calculated by the "Monowell" module), wellhead temperature (**WHT**), or downhole pressure reading (**DHP**);
- Gradual, systematic opening of the choke (**RCV**) at well start-up, depending on variations in wellhead pressure;
- Strict control of pressure variations [wellhead **WHP**] & downhole (**DHP**) to protect the well-bore interface and downstream installation, both during start-up and in production;
- A planned stop is generally installed;
- Possible regulation of a methanol injection valve upstream of the choke (**RCV**) to prevent hydrate formation, depending on the temperature at that point (**WHT** upstream of the choke).

4.2.3.3 Specific information for gas-lift wells

The "Monowell" control algorithm for gas-lift wells is characterized by:

- Adaptation to the different phases in the life of a well exclusively by modifying settings on the detailed table. There are three possible well operating modes:
 - Naturally flowing (without gas-lift), so the well does not need gas-lift to start-up and achieve a sufficiently high, stable production rate.
 - Activated (with gas-lift), as necessary, both during start-up and production.
 - Specific situations included in this category:
 - . Wells that are able to start without assistance (to deliver low pressure gas to the compressors) but need gas-lift for nominal production.
 - . Wells that require low casing pressure for start-up and production.
 - . Semi-flowing wells that need gas-lift injection for start-up but are able to produce without it.
- Two kinds of start-up are possible:
 - **Closed** (the production choke (**RCV**) is closed during the casing compression phase). This type of start-up is reserved for wells that are difficult to start.
 - **Open** (the production choke (**RCV**) is open and tubing decompression takes place at the same time as compression of the casing);
- Gradual, systematic opening of the **RCV** choke during well start-up, dependent on variations in wellhead pressure (**WHP**), to protect the well-bore interface and downstream installations;
- A choice of production targets, selected by the control panel operator for each well, from the following list:
 - estimated production flowrate (**PLFR**, calculated by the "Monowell" module);

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- wellhead temperature (WHT);
- a combination of these two values (DUAL);
- Estimated gas-lift flowrate, based on the delta-P and position of the GLFCV (in case of failure of the gas-lift flowmeter);
- It is possible to manage a short stop with a quick return to the previous production settings without going through some of the long start-up phases. When the well is stopped, the "**Monowell**" module counts down a "short stop" time delay: if the well is restarted before the end of this delay, the "**Monowell**" module compares the wellhead temperature with the predefined thresholds (in the detailed table) to optimize and reduce the time required to restart.
- Continuous optimization of the injected gas to oil production ratio, while maintaining well stability; the "**Monowell**" module is programmed to open the production choke (**RCV**) to the optimum value and optimize the gas-lift flowrate (**IGR**) by reducing it to a minimum. These two values are defined in the detailed table of parameters. The "**Monowell**" module keeps the well on target for production at all times by sequential regulation of the production choke (**RCV**) and **GLFCV**.
- Possibly regulating the chemical injection valve automatically according to the well state.
- Possibly taking into account a pressure limitation imposed by a regulator (**FLP**) on the production flowline: if the pressure set point is exceeded, the regulator forces closure of the production choke (**RCV**) to avoid damaging the flowline.

Special case of double string wells

A module is dedicated to double completion gas-lift wells where both strings are producers.

For this kind of application, each string is independently managed by a gas-lift "**Monowell**" module and then linked to a double completion "**Monowell**" module that ensures:

- Sequence synchronization on each string;
- Automatic restart of both strings;
- A gas-lift flow-rate set point calculated according to the requirements of each string.
- Interface with the "Multiwell" module to ensure consistency of the start-up and load-shedding commands to each string.

Special case of "coiled tubing gas-lift"

This module is dedicated to wells activated by coiled tubing, a specific application for gas-lift wells. In this application, the gas-lift is injected directly at the bottom of the well, through a small pipe located inside the tubing.

Coiled Tubing Bottom Pressure (**CTBP**) is calculated from the coiled tubing head pressure and the (**CTHP**) gas-lift flowrate (**IGR**), taking into account the gas column weight and friction losses. The **CTBP** is related to the downhole pressure (**DHP**), used as a basis for calculating the production flowrate estimate.

The production target may be wellhead temperature (**TWHT**), production flowrate (**PLFR**), dual (combined between **WHT** and **PFLR**), or **CTBP**.

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4.2.3.4 Specific information for ESP wells

The "Monowell" control algorithm for **ESP** wells is able to:

- Manage both naturally-flowing and **ESP**-activated well phases (both modes are possible): during well start-up, the "**Monowell**" module checks whether the well is naturally-flowing mode (wellhead temperature increase during tubing decompression) or **ESP**-activated. During production, the "**Monowell**" module is able to switch the well automatically to naturally-flowing mode.
- The algorithm handles the well equipment: well activation by one or two **ESPs**, presence of a variable-speed drive to run the **ESP**, presence of a production choke actuator (RCV), gas ventilation via the annulus or not, with or without an APCV on the gas ventilation line.
- An production target based on the possible "equipment" configurations and the control panel operator's choice:
 - frequency;
 - a defined choke opening (**RCV**);
 - the pump suction pressure (**DHP**) or the height of liquid above the **ESP** ('submergence' level, (**CSH**) calculated by the "**Monowell**" module);
 - wellhead temperature (**WHT**);
 - estimated production flowrate (calculated by the "**Monowell**" module).
- If a variable-speed drive is installed, the frequency set point input to the variable-speed drive is managed, to ensure a gradual, systematic increase/decrease.
- The frequency set point is calculated from the following factors:
 - the selected production target;
 - well reaction: pump suction pressure (**DHP**) (or **CSH**) is a representative well reaction criterion;
 - ESP reaction: motor amperage (**MIT**) is a representative criterion of ESP stability and effective operation;
 - process reaction: wellhead pressure (**WHP**);
 - a load-shedding signal from the "Multiwell" module;
- Deals with the most common electrical issues on the ESP: limits the number of start-ups per hour, setting the interval between start-ups, and controlling backspin. The precise values defined by the variable-speed drive manufacturer are input as settings;
- Vibration measurements on 3 axes X, Y, Z (and X', Y' and Z', if two sensors are available), motor amperage, wellhead pressure, Delta P across the production choke, annular gas flow (in case of ventilated gas), bottom hole pressure, motor temperature, and submergence level are taken into account to limit speed;
- Actions on the pump "Start/Stop" command and **PWV** and **SDV** valves (ventilated gas);