



Exploration & Production

GENERAL SPECIFICATION

Field Operation

GS EP EXP 159

Pipeline Management System

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1. Scope

1.1 Definitions

A Pipeline Management System (PMS) is a software application designed for providing Field Operations personnel with support where production facilities multiphase flow conditions.

1.2 Applicability

This GENERAL SPECIFICATION applies to a transportation system carrying hydrocarbon fluids and water under more than one single phase between distant production facilities.

Plant and surface facilities piping are not impacted.

This specification assumes that all sensor measurements, actuators commands and shut down status are retrieved and stored in real time in an historical data base.

1.3 Purpose

This specification describes the minimum requirements of a PMS.

2. Glossary

BSW: Basic Sediment Water

CCR: Central Control Room

CGR: Condensate Gas Ratio

ESD: Emergency Shut Down

FAT: Factory Acceptance Test

GOR: Gas Oil Ratio

HMI: Human Machine Interface

MAT: Model Acceptance Test

MPFM: Multi Phase Flow Meter

OCWR: Overall Control for Wells and Risers

PCS: Process Control System

PSS: Process Safety System

PMS: Pipeline Management System

PVT tables: Thermodynamic tables

RTDB: Real Time Data Base

SAT: Site Acceptance Test

SIE: System Information Enterprise

SII: System Information Industrial



3. 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
Not applicable	



4. Design principles

PMS shall belong to the Operational ENTITY SIE and shall be disconnected from SII network.

PMS shall pick-up field data in the PRODUCTION FIELD RTDB and may store calculated data in the same RTDB.

PMS may include five modes of operation:

- Live mode: to provide operators with key parameters related to current operation. This is achieved by the synchronisation of PMS with field data (collected from RTDB) in such a way that the embedded PMS dynamic model mirrors the real production operations
- Calibration mode: an enhanced model calibration mode
- Replay mode: to re simulate an operational period in the history
- Look-ahead mode: to provide Field Operations personal with early warning by predicting the short term production facilities trend
- Off-line mode: to conduct training, perform “what-if” and planning sort of simulations.

The live and calibration modes are mandatory for Field Operations support, and shall be included in any PMS development. In practice, the off-line mode is also always part of the specifications. The two other ones are left optional.

The selected operating modes shall run simultaneously without compromising the speed of each mode.

PMS Human Machine Interface shall be remotely accessible from any authorised workstation connected to the SIE network of the Operational ENTITY. The number of simultaneous PMS end-users shall be defined in the project specification.

5. Dynamic Model Requirements

5.1 Modelling Philosophy

The overall philosophy of the modelling shall be to:

- Calculate the flow, pressure, temperature, liquids hold-up distribution along the multiphase transportation system
- Calculate global parameters such as liquid content of the pipeline, hydrocarbon and water phases
- Reproduce the phenomena which orient and constraint the production operations
- Take into account the connected streams that impact the material balance (gas lift, methanol injection, etc.)
- Account for the flow assurance issues like hydrate and wax risks, emulsion, slugging, liquid accumulation, cool down
- Account for preservation operations such as pigging, depressurization, recirculation, chemical injections
- Include enhanced calibration functions.



5.2 Dynamic model scope

The dynamic model scope and battery limits are case dependant and shall be defined in a document, peculiar to each development.

The dynamic model shall be custom designed for tag names, configuration data, heat and material balance, process function performance and control strategy.

Within the dynamic model scope, all the production operations performed from the CCR have to be simulable by the same model.

Within the relevant scope, the dynamic model shall include:

- An inflow function
- A thermodynamic package for phase equilibrium and fluid properties calculation
- A multiphase flow model for fluid transportation modelling, capable of handling gas, and non-miscible liquid phases
- A process model for the receiving facilities and/or the intermediate processing units
- ICSS inputs / outputs for the relevant scope, all collected from field RTDB
- The simplified control logic of the simulated systems.

The model used in the calibration mode, described in Section 7 of the herein specification, shall be the steady state version of the dynamic.

5.3 Inflow function

At the upstream battery limit, a robust, reliable and flexible inflow function shall be developed.

The selected solution shall depend on where the upstream battery limit is:

- At the well bore: a well model, including the near well bore, well tubing and wellhead, is required. The configuration of the inflow function (static pressure and temperature, well productivity index, reservoir pressure) shall be performed from PMS HMI
- Elsewhere (at the top of the well, downstream a process unit on a production platform, etc.): a flow metering device (MPFM, virtual flow estimation...) is mandatory at the model battery limit

5.4 Thermodynamic package

Phase equilibrium and fluid properties shall be computed by a thermodynamic package or by PVT tables.

At each source battery limit, the configuration of the fluid data (at a minimum the vapour fraction and water fraction) shall be performed from the HMI.

5.5 Multiphase flow model

A multiphase flow model shall simulate the fluid behaviour versus time in the multiphase transportation system. It shall be predictive enough for providing value prior start-up, when no data are available for flow model calibration, and flexible enough for being tuned when field data (collected from RTDB) becoming available.



Upstream, it shall be combined with the inflow function (to provide the boundary condition), and downstream with the process model of the receiving facilities.

On the relevant scope, the multiphase flow model shall include or be connected with equipments involved in production operations (valves, chemical injection points, activation functions, intermediate process units).

The multiphase flow model shall be developed with SOFTWARE provided by the PMS Supplier, or by a PMS Supplier Subcontractor.

The SOFTWARE shall be based upon coupled mass, momentum and heat transfer conservations equations, completed with closure laws, applied and solved on flow segments. The PMS architecture shall allow, as far as practicable, the up-date of the closure laws.

A slug tracking functionality, which consists in liquid slug follow-up along the transportation system, may be required in the project specification.

The PMS Supplier or its Subcontractor shall be responsible for the final configuration of the multiphase flow model (fluid definition, topography segmentation, ambient conditions definition, wall thermal properties definition...), even when Company provides the first model configuration.

The ambient conditions shall be modifiable from PMS HMI, the topography and wall properties shall be displayed.

The use of the SOFTWARE for the PMS development shall have been approved by Company before the PMS project is kicked-off.

5.6 Process model

A receiving facilities process model shall simulate the production-limiting effects (pressure control loop, liquids handling capacity and control logic) that will affect the multiphase transportation system.

The receiving facilities process model may be developed directly with the SOFTWARE or a with a process simulation application like, but not limited to INDISS, K-SPICE, UniSim, DYNsim.

The receiving facilities process model shall be connected with the multiphase flow model.

The project specification defines the detailed scope and additional requirements related to the modelling. At a minimum, the first receiving capacity (separator, slug-catcher) shall be included in the process model. All intermediate processing facilities like boosting, separation, subsea processing, shall be simulated and included in the dynamic model.

The process model configuration parameters shall be modifiable from the PMS HMI.

5.7 Automation

5.7.1 Control logic

The dynamic process model shall include the control loops of the simulated systems. The control loop configuration parameters shall be modifiable from the PMS HMI.

The modelling of advanced control logic like OCWR is not requested in the herein General Specification.



5.7.2 Safety logic

The modelling of shutdown sequences and safety logics is not requested in the herein General Specification.

5.7.3 Alarms

Within the model scope, PSS and ESD alarms shall be included in the model. When the calculated value of a given parameter exceeds its threshold, it shall be flagged on the HMI.

Alarms threshold shall be modifiable from PMS HMI.

5.7.4 Field Operations Devices

Operation of relevant FOD shall be allowed through PMS HMI.

5.8 Accuracy criteria

At Model Acceptance Test, the entire dynamic model (inflow function, multiphase flow model, process model) shall be compared against reference data, either simulated data, or field data (collected from RTDB) if they are available. The deviations between model outputs and reference data shall be calculated at key locations.

In steady state conditions, the model accuracies defined in Table 1 shall be met:

Temperature drop between two points And/or Temperature deviation at given points	10 % < 3°C (absolute value)
Pressure drop between two points	10 %
Flow rates	5 %

Table 1. PMS accuracies table

At FAT and SAT, **the application shall be compared against field data** (collected from RTDB).

- In steady state conditions, the accuracies defined in Table 1 shall be met
- During transient operations, the calculated moving average of the parameters (pressure, temperature, flow) shall not deviate by more than 10% from the measured ones, both in terms of amplitude and of time
- The calculated standard deviation for these parameters shall be in the same order of magnitude than the observed one. For instance, a fully flat flow rate is not acceptable if the observed flow rate exhibits significant and repetitive perturbations
- The receiving facilities process model will be used for checking that the transportation system outflow is consistent.

The accuracy criteria shall be met with constant calibration parameters.

6. Live mode

The Live mode workflow is illustrated on Figure 1: the system uses synchronization data coming from PRODUCTION FIELD RTDB (valve positions, command status) as boundary conditions to the PMS embedded dynamic model.

Inputs can be overwritten by the user through HMI.

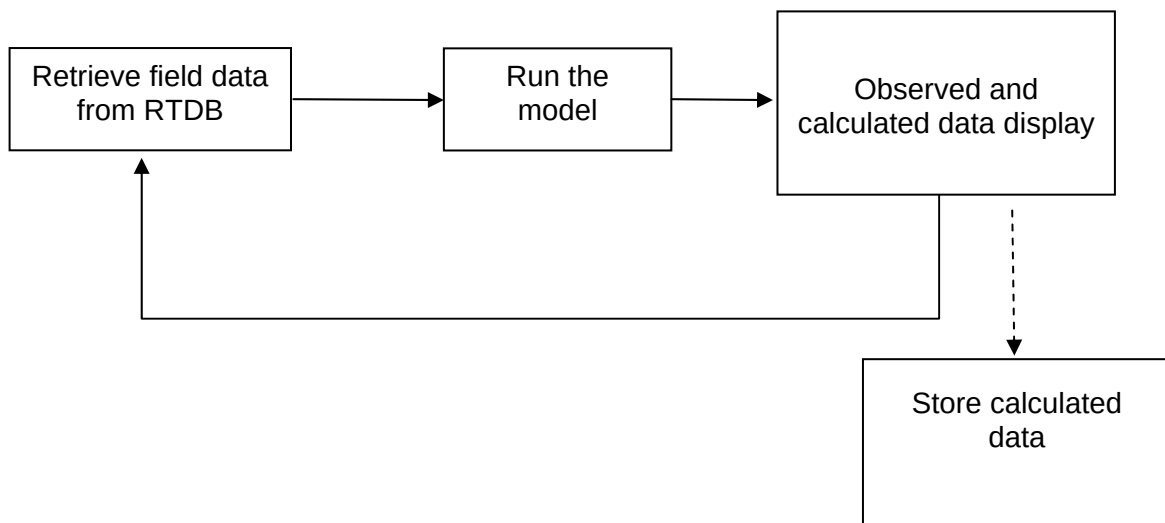


Figure 1. Live mode workflow

6.1 Interface with RTDB

Synchronisation data encompass valve positions, controller set points, shut down status and others commands necessary for mirroring the operations in the simulator.

Observed data are the sensors measurements within the simulated scope.

PMS shall retrieve synchronisation data and observed data from the RTDB.

6.2 Execution speed

The execution speed shall be locked to one.

6.3 Monitoring

Application monitoring and application control is achieved with a dedicated Human Machine Interface.

Data presented on the Human Machine Interface shall include:

- Models configuration data
- Production fluid data, at a minimum the fluid GOR or CGR and fluid BSW
- Synchronisation data
- Observed data and calculated data at sensor locations

- Fluid and flow properties (as profiles along the transportation system and at specific locations): Pressure, Temperature, Flow rate and velocities of all fluid phases, Liquid Hold-Up, Water hold-up, flow regime, distance from hydrate region, etc.
- Integrated volume and mass properties like total liquid content, and water content
- Travel time between transportation system inlet and outlet
- Mass balance for gas, condensate (or oil) and water
- Fluid phase envelope and transportation system curve.

PMS outputs shall be stored in an historical data base provided by PMS Supplier.

Some PMS outputs may be stored in the PRODUCTION FIELD RTDB.

6.4 Warnings

Under conditions, warnings shall be flagged on the HMI. This may for instance be high liquid inventory in the transportation system, fluid temperature close to hydrate conditions, unexpected mass balance.

For that purpose, an Alarm Management System (colour code, acknowledgement, history) shall be developed and presented on the PMS HMI. Such Alarm System shall be consistent with the one used on PRODUCTION FIELD.

6.5 Cyclic Snap

Saving of snap files shall be automated at a configurable time interval from one minute to one week.

In addition to the automatic snapshot facility, it shall be possible to save the dynamic model conditions on the fly at any time.

6.6 Availability

PMS down time shall be as reduced as possible; the target of 30 minutes per day shall not be exceeded.

6.7 Catch-up mode

In case PMS has stopped, when restarted, PMS shall catch up the current situation by simulating all the events that occurred during the time PMS was out of service. In such downgraded mode, PMS speed shall be as high as possible.

7. Calibration mode

A calibration workflow shall be designed and implemented.

PMS Supplier shall provide the list of calibration parameters with bounds and ranges of actions. Using mono variable tuning loops is tolerated provided that an enhanced calibration mode is designed and delivered.

The enhanced calibration mode shall provide in one step the calibration parameters values which give the best match between model outputs and reference data. Reference data may be spot data (snapshot), or history data. The range of uncertainty of reference data shall be accounted for.

The calibration parameters values shall be displayed on the PMS HMI.

The model used in the calibration mode shall be a steady state version of the dynamic model.

The calibration parameters values shall be exportable to the other modes of PMS execution.

8. Replay mode

The replay mode workflow is shown on Figure 2. Field operations personal run the model using historical data as synchronisation data.

The execution shall be as high as possible, and greater than two times real time.

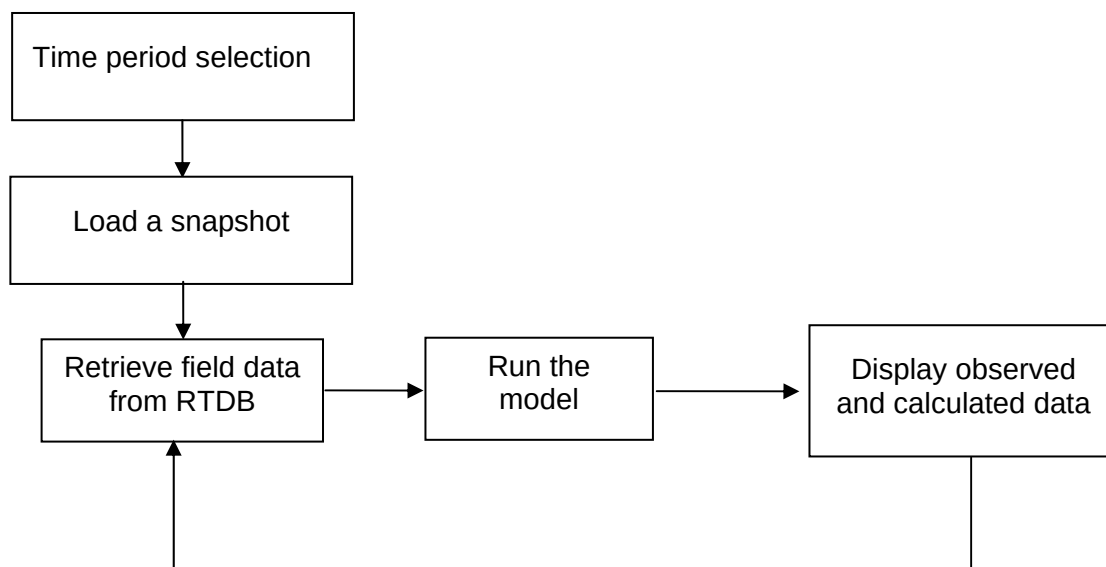


Figure 2. Replay mode workflow

9. Look-ahead mode

The Look-Ahead mode provides short term production forecast as illustrated on Figure 3: starting from the current conditions, the model is run as fast as possible assuming that synchronisation data remain unchanged.

The execution speed upper limit is fixed at two times real time, knowing that specific requirements are defined in the project specification.

The model running in look-ahead is identical to the model running in other modes, and the model can load a snap file generated by the live mode.

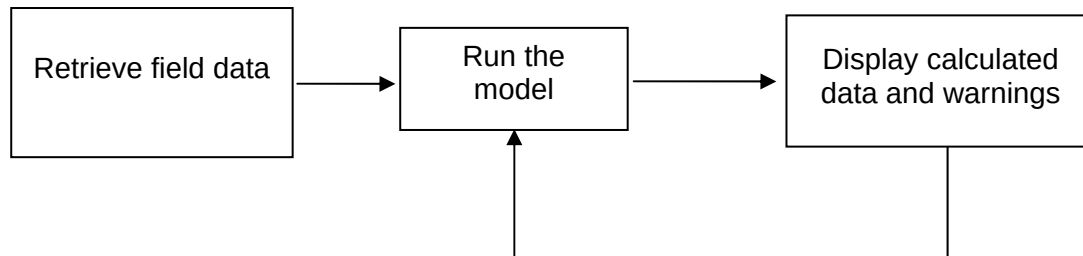


Figure 3. Look-ahead mode workflow

10. Off-line mode

A PMS running only the off-line mode may be delivered earlier as it is not synchronised with field inputs. This shall be agreed on Project Schedule Plan.

As any dynamic simulator, it shall include control simulation functions like run / freeze, save / load, speed up / slow down.

The model running in off-line mode is identical to the model running in the live mode.

User shall have the capacity to apply to the model a sequential list of actions. For that purpose, HMI shall include a user-friendly scenario definition tool.

An interactive and engineer oriented HMI shall be delivered where all calculated variables can be displayed (local tags, trends, profiles)...The access to the model parameters shall be contextual.

The execution speed upper limit is fixed at two times real time, knowing that specific requirements are defined in the project specification.

11. PMS acceptance workflow

Model Acceptance Test shall be carried out at PMS Supplier office.

Would the MAT be run prior field Start Up, an additional model testing session shall be run after field data are available.

MAT will be witnessed by Company personnel.

PMS FAT shall occur step by step:

- FAT for the off line mode shall occur after the corresponding successful MAT
- FAT for the live and calibration modes shall only take place after field data have been provided to PMS Supplier, loaded in a dummy field RTDB and installed in PMS Supplier offices. Such FAT shall include a link test between dummy RTDB and PMS.

PMS SAT and roll-out shall occur step by step:

- SAT and roll-out for the off line mode shall occur after successful corresponding FAT
- Decision to roll-out in the Operational ENTITY the live mode PMS will be taken after FAT



- A remote connexion between the server which runs the PMS and a location from where PMS Supplier will conduct PMS supervision operations, bug fixing, model calibration, shall be built- up and operational at the live mode roll-out date
- The Extended Test Period will then begin and shall last for a minimum period of 6 months. During this period PMS will be subject to normal operation. At the end of the Extended Test Period, PMS acceptance certificate will be signed off, provided conformity with the specifications.

Warranty will start when PMS acceptance certificate is delivered.

12. Maintenance

As PMS requires significant support, Operational ENTITY and PMS Supplier shall agree upon a maintenance agreement.

13. Scope of supply

The scope of supply shall include the software application, the licence, the hardware, the documentation and services needed for meeting the requirements.

13.1 Software application and licence

All the software components (modules libraries, executable files, models, graphics, middleware) and licence rights needed for meeting the PMS specifications.

13.2 Hardware

The scope of supply includes the specification, procurement, supply of the hardware to run the PMS in accordance with the specifications

In minimum, it shall include:

- the server (s) for PMS application execution
- one engineering workstation, loaded with PMS HMI.

13.3 Documentation

The documentation shall include as a minimum:

- Functional Detailed Specification
- Testing procedures and reports
- Installation Guide
- User Manual
- Maintenance Manual.

13.4 Services

All the services needed to deliver the PMS according to the specifications from project kick off meeting to the end of the extended test period.