



Exploration & Production

GENERAL SPECIFICATION

Field Operations

GS EP EXP 403

Production Availability Studies of Oil and Gas Facilities
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1. Scope and Organisation

1.1 Purpose of the specification

The purpose of this general specification is to provide requirements for the performance of production availability studies (PAS).

1.2 Applicability

This general specification shall apply to all oil and gas installations engineered and/or operated by Total EP. This includes the case of major modifications on existing installations, including the tie-in of a new installation to an existing one.

1.3 Organisation

Within OPS, EXP/SRI holds the technical expertise in probabilistic analysis, modelling and calculation. EXP/SRI advises any DGEP entity performing production availability studies in the areas of information, training and technical assistance. This includes:

- Selecting and contracting qualified Contractors ;
- Facilitating relationships between Company and Contractor ;
- Supervising Contractor works all along the progress of the study ;
- Validation and consolidation of the SOW (See §5.3.2) ;
- Qualification of the type of models and tools proposed by the Contractor;
- Validation of results and deliverables ;
- Etc ...

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
ISO 20815	Petroleum, petrochemical and natural gas industries. Production assurance and reliability management

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 EXP 405	Standard reliability data report

3. Abbreviations & Symbols

CCF	Common Cause Failure
CMF	Common Mode Failure
ESD	Emergency Shutdown
FMEA	Failure Mode and Effects Analysis
IS (MAI)	Injection shortfalls
PS (MAP)	Production shortfalls
MoM	Minutes of Meeting
MTTF	Mean Time To Failure
MTTR	Mean Time To Restore
PAD	Production Availability Diagram
PAS	Production Availability Study
P&ID	Piping and Instrumentation Diagram
PFD	Process Flow Diagram
RBD	Reliability Block Diagram

SIMOPS	Simultaneous Operations
SOW	Scope Of Work
λ	Failure rate
μ	Active repair rate
γ	Probability of failure due to demand

4. Terms & Definitions

Active Repair Time	Part of the maintenance time during which a maintenance action is performed on an item, either automatically or manually, excluding logistic delays Note: it is an intrinsic item parameter, contrary to logistic delays which are in relationship with operation and maintenance policies.
Availability	The availability is the probability that a machine or system will be able to fulfill its required function under certain conditions at a given time. Note 1: Availability considers only two states: "operating" and "failure" and is, thus, very different from production availability. Note 2: Average availability is thus defined as the amount of time during which a component, machine or system was working normally as required.
Consolidated scope of work	Improved SOW obtained from an intensive question/answer process between the Contractor and the Company. This shall be performed at the very beginning of a production availability analysis in order to: - Identify the key indicators to estimate. - Verify that the actual problems are correctly identified
Deliverability	Ratio of deliveries to planned deliveries over a given period of time when the effect of compensating elements such as substitution from other producers and downstream buffer storage is included.
Emergency Shutdown	Control actions undertaken to shutdown equipment or process in response to a hazardous situation.
Failure	Termination of the ability of an item to perform a required function.
Common Cause Failure	Failure of different items resulting from the same direct cause, occurring within a relatively short time, where those failures are not consequences of another (ISO 20815). Note: CCF limits the improvement obtained by implementing redundancy.



Common Mode Failure	Failure of two or more components in the same way,
Critical failure	Failure of an equipment unit that causes an immediate cessation of the ability to perform a required function.
Degraded failure	Failure that does not cease the fundamental function(s), but compromises one or several functions.
Failure mode	Effect by which a failure is observed on the failed item.
Failure Mode and Effects Analysis	Systematic method identifying the effects on a system of each component failure mode. Note: FMEA will be used here to identify the effects on the production of the production facility.
Failure Rate	Probability for an item to fail between t and $t+dt$ provided that it has run without failure over $[0, t]$.
Flaring Policy	Description of flaring consents and constraints..
Flow Diagram	A directed graphical network made of modules representing the various parts of the production system with their given production capacities linked together in order to represent the circulation of the production flow.
Logistic Delays	Accumulated time during which maintenance cannot be carried out due to necessity to acquire maintenance resources excluding administrative delays.
Maintainable item	Item that constitutes a part, or an assembly of parts, that is normally the lowest level in the equipment hierarchy during maintenance (ISO 20815)
Operation Philosophy	Rules describing how the installation is operated. Note: Safety, maintenance, spare part and flaring policies depend on the given production installation. They are likely to have a strong impact on production availability performance.
Preventive Maintenance	Maintenance carried out at predetermined intervals or according to prescribed criteria, and intended to reduce the probability of failure or the degradation of the functioning of an item.

Production Availability	Production availability is the ratio (expressed as a percentage) of actual production over the production forecast for a given period of time. Note 1: It is important to check the parameters of this formula as early as possible since they may vary during the study (production profile, nominations, etc.). Note 2: Actual production figures and the production reference level used to calculate PA must be clearly indicated to facilitate the interpretation of production availability. Note 3: The production availability of several systems does not simply consist of a sum or a product of their respective production availability figures. Note 4: Production availability is not necessarily associated with oil or gas production, but could, for example, concern water, steam, or energy injection, etc.
Production Availability Diagram	A directed graph describing the links between production items and utilities needed to run these items in order to represent the production capacity of the facility under study.
Reliability	Reliability is the probability that a machine or system is able to fulfill its required function continuously under certain conditions over a given time period. Note: This indicator is closely linked to the MTTF.
Reliability Block Diagram	A directed graphical network made of modules linked together to represent the logic of a two states system.
Repair Rate	Probability for an item to be repaired between t and $t+dt$ provided that it is under repair over $[0, t]$.
SIMOPS	Simultaneous Operations (SIMOPS) of production and construction or production and well activity may request that production is partially or completely shut down for safety reasons.

5. General methodology

The relevance of a PAS is improved by using a precise methodology to gather and analyse a maximum amount of data about the system being studied, in order to design a model as similar to the real system as possible.

5.1 Production Availability Studies Along the Life Cycle of the Facility

The level of details and results / deliverable of a production availability study shall be adapted to the life cycle of the oil and gas facility.

Three levels have been identified:

- Coarse production availability study:
 - It is performed during the Pre-Project or Conceptual phase. It provides a decision aid to select the most efficient architecture and aims at establishing which mean production availability is achievable.



- High level production availability study:
 - It is performed during the Basic Engineering phase. It aims at consolidating the results of the coarse study, and at identifying the main contributors to the production losses in order to improve the design.
- Detailed production availability study:
 - It is performed at the Detailed Engineering phase and aims at validating the final design and at orienting the maintenance strategy on the top contributors to production losses so that the design is likely to meet the production availability targets.

5.2 Deliverables

During a production availability study, the Contractor shall provide working documents and a final report.

The working documents allow the Company to follow the work progress and to detect any difficulty as soon as possible. These documents shall be produced according to the general methodology presented in §5.

The actual content and the level of detail of those documents depend on the level of analysis (coarse, high or detailed) and of the size of the system under study.

The final report is based on the material contained the working documents and is published at the end of the study.

5.3 Production Availability Study Methodology

5.3.1 Main steps

Whatever the level of detail of the production availability study the Company shall prepare a detailed scope of work (SOW) defining namely:

- The objective of the study and its context;
- The boundaries of the system(s) under study;
- The expected level of details of the study;
- The parameters to be evaluated;
- The deadline for the issue of the deliverables.
- Attached to the above SOW the Company shall provide all the documents allowing the Contractor to understand the scope of work and prepare his commercial offer for the work. Depending on the phase in the life cycle this should also include PFD's, PID's, operation and maintenance philosophies, safety logic diagram, and any other relevant documents available.

Whatever the level of detail and based on the SOW, the Contractor shall make a work proposal based on a lump sum and structured in nine steps:

1. Definition of targets and of battery limits.
2. Consolidation of the scope of work;
3. Identification and analysis of the functions of the oil and gas facility;

4. Writing and gathering of assumption sheets;
5. Reliability data gathering;
6. Causes and effects analysis of the events inducing a production loss;
7. Production availability modelling and calculations;
8. Reporting
9. Schedule

5.3.2 Targets, battery limits and SOW consolidation

The following shall be strictly adhered to by both the Company and the Contractor:

- Terminology and definitions presented in chapter 4 are used;
- All utilities (electrical power, fuel gas, gas lift, compressed air, ...) are listed and those to be discarded in the study are agreed by the Company;
- Operation constraints are listed and those to be discarded in the study are agreed by the Company. This may include but is not limited to:
 - Maintenance policy, flaring policy, production policy, water injection policy,
 - Evolution of the production potential,
 - Spare part policy, mobilisation of resources policy,
 - Preventive maintenance, well maintenance and testing / monitoring,
 - SIMOPS,
 - Gas nomination,
- All external constraints (e.g. due to third party) are identified and those to be discarded for the study are agreed by the Company;
- The flows (export oil, export gas, injected water, flared gas, ...) to be considered are clearly identified;
- Etc.

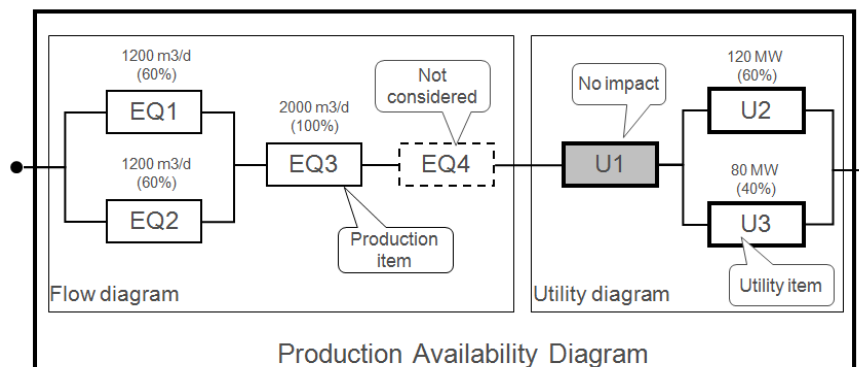
The SOW shall be consolidated within step 2 to avoid any misunderstandings between Company and Contractor. The consolidated SOW shall be written by the Contractor once he has got sufficient knowledge of the study and this shall be covered in the lump sum proposal.

5.3.3 Analysis of the functions

Step 3 aims to identify and analyse:

- The various functions of the system under study which participate to the production (e.g. compression, ...), the various units belonging to these functions (e.g. compression train, ...) and, depending of the level of detail of the production availability study, the various pieces of equipment belonging to these units (e.g. inlet scrubber);
- The functional links between the above elements for the purpose of the production availability study;
- The redundancy levels.

This analysis shall be summarized graphically by a "Production Availability Diagram" (PAD) which is a way to ensure a common understanding of the functioning of the system(s) between the Company and the Contractor. It can generally be directly drafted from the PFD's/P&ID's and technical documentation provided for the performance of the study. The level of detail is in relationship with the level of detail of the production availability study.



The above figure gives an example of such a PAD comprising a flow diagram on the left hand side and the utility diagram on the right hand side.

To make easier the understanding of PAD's we suggest adopting the following symbolism:

- Single lines boxes for production items.
- Double lines boxes for utility items.
- Dotted lines boxes for items which are not considered.
- Grey background for items with no (or negligible) impact on production.

In case of redundancy, it may be confusing to indicate the module capacities by using percentages (100%, 50%, 33%, etc.) when dealing with complex systems or production profiles varying along the time. Therefore the capacity shall be indicated: in barrels per unit of time, standard cubic meters of gas per unit of time or power with, possibly, the % within parenthesis.

If several fluids have to be considered (export gas, export oil, flared gas, water injection, etc.) several PAD are needed.

Assumption sheets

5.3.4 Assumptions

Identifying all the assumptions is the most important step in a production availability study. These data (operating philosophy, well intervention, industrial environment etc.) are used as a basis for modelling the system to be studied and have an immediate impact on the outputs.

It is, therefore, essential to check systematically that all the assumptions are valid. This concerns all assumptions in the following fields:

- Maintenance and inspection data:
 - Site impact (onshore, offshore, scattered, remote, etc.)
 - Geographical impact (lead times for logistics, spare parts, crew mobilisation etc.)
 - Frequency of preventive maintenance operations and time required.



- Production profile,
- Nomination,
- Well management, (SIMOPS, reconditioning etc.)
- Rare events,
- Flaring policy,
- Wastewater discharge policy
- Load shedding policy,
- Specific environments (mines, arctic, etc.)
- Human factor,

Assumptions are controlled and monitored on the basis of two documents:

- The assumption sheets,
- The assumptions register.

5.3.4.1 Assumption sheets

The Contractor is in charge to build and to fill in the set of assumption sheets (revision 0) from the available documentation.

An assumption data sheet must be completed for each assumption to be validated. This document is used to track each assumption and specifies the following:

- Subject,
- Purpose,
- Context,
- Sources,
- Status,
- Any comments made by the specialist concerned,
- Validation procedure.

Name of study Assumption data sheet		
N.º: XX		Revision: XX
Subject:	Specify the field concerned by the assumption	
Purpose:	Clearly specify the purpose of the assumption	
Description		
Explain the assumption and its context. (Use extra pages if necessary)		
Reference:	State sources used.	
Section to be completed by the headquarters discipline or specialist		
Status:	☐ Approved ☐ Rejected	
Comments:		
If an assumption is rejected, explain why and suggest an alternative. (Use extra pages if necessary)		
Released by	Name/Entity	Date: dd/mm/yyyy
Authorised by:	Name/Entity	Date: dd/mm/yyyy

Figure 1. Example of an assumption sheet form.

Any comment or modification on an assumption sheet will involve a revision of its previous version.

An assumption will be considered as frozen when the associated assumption sheet is validated and approved.

5.3.4.2 Assumptions register

All assumption sheets are recorded in the assumptions register which is used to monitor the progress of the evaluation procedure for all the assumptions considered in the PAS.

Assumption data sheet N°	Subject	Validated by	Approved by
01			
02			
03			
04			
05			
06			
07			
08			
09			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
...			
...			

Figure 2. Example of an assumptions register form

5.3.5 Data gathering and validation.

5.3.5.1 Type of data

Production availability calculations require three types of data regarding

- the operation of the installation(s);
- the industrial / natural environment of the installations (weather conditions, availability of external power supply, by example);
- the reliability and maintainability of the equipment.

The human factor shall be analysed by the Contractor to identify the best way to take it into consideration in the calculation. This shall be agreed between the Company and the Contractor.

5.3.5.2 Operational and external data

The Contractor shall identify the operational and external data needed for the study and the Company shall provide these data. Operational and external data are thereby described in their dedicated assumptions sheets.

They usually include, but are not limited to:

- Operation modes of the installation (manned/unmanned mode, day/night shifts, etc.);
- Overproduction capacity when relevant;
- start up and ramp up durations for unit, system and facility;
- Maintenance strategy (immediate, delayed, temporary intervention for restoration);
- Possible back-ups and reconfigurations;
- load shedding during power shortfalls;
- Logistics strategy (e.g. spare parts stored onsite or not);
- Availability, mobilisation procedures and delays, travel duration for the intervention means and teams (helicopter, supply boat, drilling vessel, ROV, etc.);
- Availability of external supplies (electrical power, products, etc.);
- Weather conditions.
- etc.

5.3.6 Reliability data gathering

The basic reliability parameters (failure and repair rates, probability to fail upon demand) used in production availability calculations shall come from the following sources by order of priority :

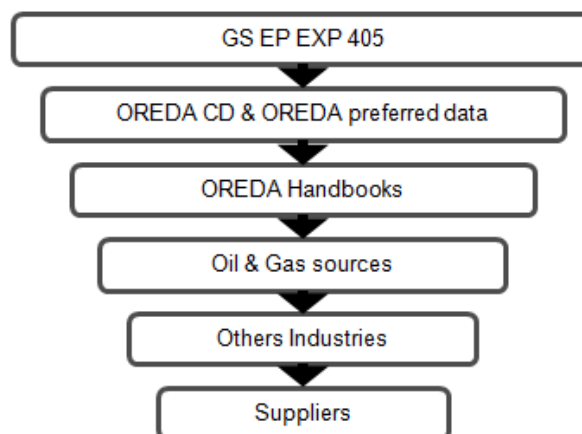


Figure 3. Data sources hierarchy

In some instances specific data collections and processing may be needed from production facilities of the Company. This shall be specified in the SOW and the Contractor shall describe how he is going to manage this task.

Early life failures shall be considered for new installations and managed as indicated in the **GS EP EXP 405**.



The use of other reliability databases shall be explained, justified and referenced in an assumption sheets for equipments which are not dealt within the **GS EP EXP 405**.

5.3.7 Causes and effects analysis

5.3.7.1 Objective

The causes and effects analysis aims at identifying the events which may cause production losses and their consequences on the production availability.

The following rules have to be applied for each type of production availability studies:

- The causes and effects analysis shall be performed on the elements identified by the analysis of the functions.
- Both planned and unplanned events which may induce a production loss shall be considered.
- If several fluids are considered, the consequence on each of them shall be analysed.
- The causes and effects analysis shall be more focused on effects than on causes.
- The analysis shall be done in a systematic manner, based on systematic methods.

5.3.7.2 Causes and effect analysis according to the type of study

- In case of coarse and high level production availability studies

High level cause and effects analyses shall be carried out on global units by using a form like the example shown hereafter. Possible compensating measures (immediate or delayed) shall be identified at this level of analysis.

As the percentage of production provided by a given unit varies according to the production profile, the production capacity shall be indicated in production units (barrels per unit of time, m³ per unit of time, kW ...) to avoid any confusion. Percentages (%) may be indicated within parenthesis. When several fluids have to be considered, the form should be adapted accordingly.

Restoration parameters (see check list in Appendix 2 and glossary) shall include both the active repair time (related to the unit) and the other delays (related to the operational environment) due to logistics, resource mobilisation, operating mode (manned/unmanned, day/night shifts ...) etc.

SYSTEM	Train	Production capacity upon shut-down	Restoration parameters		Comments
HP separation	\	0	μ or MART(*)		
HP compression	A	1200 (60%)	μ or MART(*)	start-up time 1 train	Increase of the production of B from 50% to 60%
	B	1200 (60%)	μ or MART(*)	start-up time 1 train	Increase of the production of A from 50% to 60%
	Both	0	μ or MART(*)	start-up time of facility	
(*) μ = repair rate, MART= Mean Active Repair Time					

Table 1. Example of Cause-Effect form

This form may be adapted according to the specific needs of a production availability study. The column for comments allows indicating any relevant information about what is done when the failure occurs (Increase the production of a redundant unit, spare part policy, needed tools, preservation operations, ramp up when restarting, etc.)

- For detailed production availability studies

A formalised conventional Failure Mode and Effects Analysis (FMEA) shall be performed in addition at item level (e.g. pressure transmitter, control valve). The form used for performing this FMEA shall be adapted to the specific needs of the production availability study. The same principles as above shall be implemented. The column "effect" of the FMEA shall be replaced by the "production capacity upon failure" and some columns may be added to indicate the "restoration parameters". If more convenient for the analyst this may be split between a form for the cause and effect analysis and another one for the restoration parameters.

The basic events for this FMEA shall be analysed and selected from the failure modes identified for each component in the **GS EP EXP 405** given in reference in §2 . Any gap from this document shall be identified, documented, discussed and agreed by the Company.

When relevant, critical and degraded failure modes shall be identified thoroughly.

As above, if several fluids have to be considered, the table shall be adapted accordingly.

5.3.7.3 Planned events

The planned events which cause the decrease or the stoppage of the production shall be taken into account according to the target of the study. They include but are not limited to:

- Well interventions (wire-line or work over) including stoppage for rig moves and associated heavy lifts;
- Inspections of pressure vessels;

- HIPS testing and safety system testing;
- Overhauls of large rotating machines;
- Pigging operation;
- Preventive maintenance;
- Periodic tests when they induce a production reduction or stoppage.
- SIMOPS;
- Change in production profile;
- third party planned events
- etc.

The exact list of planned events to be taken under consideration has to be agreed between Contractor and Company and specified in the consolidated SOW. The relevant parameters (frequency, duration, production losses) shall be based on information provided by the Company.

5.3.7.4 Unplanned events outside the production facility

Unplanned events shall include any unplanned event occurring outside the production facility itself with the potential to cause a decrease or a stoppage of the production. They shall be taken into account according to the target of the study. Unplanned events include but are not limited to:

- Emergency Shut Down;
- Loss of electrical power (black-out);
- General utility failures;
- Upstream/ downstream outages;
- Third party unplanned events;
- Etc.

When the SOW doesn't require analysing them in detail, it may be nevertheless necessary to take them into consideration to assess the production availability properly. The exact list of such unplanned events shall be agreed between Contractor and Company and specified in the consolidated SOW. The relevant parameters (Failure and repair rates, frequency, duration, production losses) shall be based on information provided by the Company.

5.3.8 Production availability modelling and calculations.

5.3.8.1 Production availability modelling techniques

Three main types of calculations are encountered when dealing with probabilistic studies: reliability, availability and production availability (properly speaking). They shall not be confused :

- Reliability deals with the first failure of an item (component, unit, system) having two states. Reliability is mainly focused on safety but may be used in the context of production availability to evaluate the probability that the first failure will be after a given period of time. This may be a target of the study.

- Availability deals with the up-time of an item (component, unit, system) having two states. Availability is mainly focused on the time during which an item is running properly. In the context of production availability it may be relevant for single components or production trains made of components in series. It may also be used to perform "availability allocations" in order to establish requirements towards the providers of such components.
- Production availability deals with the production of a multi states (multi production levels) item (system).

Classical models for reliability (e.g. Markov graph) and availability study (e.g. Reliability Block Diagram, Fault tree) are not really relevant for production availability calculations. Therefore it is recommended to use a model adapted to production availability calculations to encompass the three topics in the same framework.

For doing that Company recommends the use of Monte Carlo simulation on models representing accurately, from production point of view, the behaviour of the production system under the occurrence of the events which are likely to occur (e.g. failures, repairs, reconfigurations, night or day ...).

The Company preferred method is the use of finite state automata (e.g. Petri Nets) but there are a number of techniques (general or proprietary), which may be used for that purpose, either individually or in combination depending of the scope of work.

When the preferred technique is not to be used, the Contractor shall demonstrate that its technique is able to:

- Deal with production availability and produce all kinds of deliverables of the SOW;
- Model properly all the behavioural aspects of the production facility described in the SOW;
- Achieve a sufficient number of simulations to trigger all events having an impact on the results;
- Reach the results in a reasonable computation time;
- Provide the 90% confidence intervals of the results.

Note 1: special attention shall be paid to software packages presented to be based on "Reliability Block Diagram". Only few of them are able to handle "Production Availability Diagrams" properly.

Note 2: special attention shall be paid to software packages developed for another purpose (scheduling, dimensioning) and where Monte Carlo simulation has been patched. They are likely to be too slow to obtain accurate results.

Company agreement on the Contractor's proposed tool shall be given by EXP/SRI.

5.3.8.2 Common cause failures / Factors

A common cause failure (CCF) is a failure leading to simultaneous or concomitant failures of several components. CCFs are likely to exist each time the failures are not completely independent. Then they may have an impact on production availability.

CCF can be split into the following categories:

- Type 1: tangible failures like failure of utilities (Power generation, Instrument Air, etc.) or external aggressions (environment, fire, etc.);

- Type 2: intangible failures like design error, equipment installation error, bad set of components, programming error, etc..

Except if the Company explicitly excludes them from the scope of work, CCF-type n°1 shall be identified, analysed and quantified by the Contractor.

When the number of affected items is small (lower than 4) CCF-type n°2 may be handled by using the conventional β factor method. When the number of affected items is large (greater than 4), the Company prefers using the shock model. Due to the number of items in series, the impact of such CCF is often negligible within a production availability study compared to CCF-type1. Nevertheless they have to be analysed by the Contractor and, when relevant, quantified (e.g. for stand-by items like fire detectors). This shall be agreed between Contractor and Company.

CCF due to human failure may be handled as CCF-type n°1 or n°2 depending on the specific production availability study. It is a part of the Contractor analysis to determine in which way this has to be done.

5.3.8.3 Uncertainty Evaluation

In many cases, only average values of the results are expected from production availability study. However uncertainties exist which depend on the model built itself, and on the following:

- Type 1: the stochastic nature of the evaluated parameters: the production availability is a random variable which is spread around its average. A measure of this uncertainty is the "standard-deviation" of this random variable;
- Type 2: the statistical nature of the Monte Carlo simulation: the accuracy of the results increases when the number of simulations increases. A measure of the calculation accuracy is the 90% confidence interval of the result (i.e. the interval in which there are 90 chances over 100 to find the true value);
- Type 3: the uncertainties of the input data: the reliability parameters are not perfectly known but their confidence intervals are generally indicated in the data sources. These uncertainties have an impact on both uncertainties of type n°1 and n°2;

Uncertainties of type n°1 (standard deviation) and n°2 (90% confidence interval) shall be systematically evaluated by the Contractor to ascertain the validity of the results, ie that enough simulations have been performed to handle properly all events having an impact on production.

The need for an evaluation of uncertainties of type n° 3 (linked to input data) shall be specifically indicated in the SOW.

5.3.8.4 Sensitivity studies

Sensitivity studies may be performed to measure the impact of various factors such as a different set of failure and repair data, alternative assumptions or facility configurations, the human factor, etc...

The number of sensitivity studies to be performed shall be stated in the SOW.

Note: it is better to identify the sensitivity studies before the model is actually built in order to avoid modifying it with the risk of introducing errors.

5.3.8.5 Type of results

For each fluid under study (e.g. gas, oil, condensates, water injection), the following results shall be provided, as a minimum:

- The cumulated losses, the cumulated production and the maximum possible production over the period of time considered, including and excluding planned shutdowns;
- The overall production unavailability and availability from the previous results;
- The list of the top ten contributors and their impact on the production / export / injection losses.

When the production profile changes, the above results shall be established on:

- A year per year basis.
- The ramp-up/start-up period.
- The plateau period.

If required by the SOW, the flared gas quantity shall be provided with its top ten contributors.

Other results may be useful, according to the objective of the study. They should be stated in the SOW. For instance:

- Intervention frequency, maintenance work load, spare parts consumptions;
- Rig or ROV mobilisation frequency and time spent for maintenance;
- Probability of major shutdown;
- Probability to meet a delivery requirement;
- Probability to meet a regulation requirement (example: time spent by people on location for unmanned platforms, quantity of flared gas, etc.);
- Overall failure frequency;
- Frequency and duration of shutdowns and /or degraded situation;
- Availability of a given equipment;
- etc.

5.3.9 Reporting

The report shall be written by Contractor and organized with:

- A brief study report, summarising the context, objectives, and results,
- A comprehensive study report, including a step by step description of the preparation and implementation of the study,
- Appendices covering the more technical aspects: computation and modelling methods used, reliability data, preventive maintenance tables, references used, etc.
- An appendix containing the assumptions register. All the assumption data sheets are appended to the register,
- An appendix presenting all the minutes of meetings (MoM) issued after each review during the study.



The final model that formed the basis for the study results is delivered to EXP/SRI.

5.3.9.1 Executive summary

The executive summary shall include:

- A reminder of the objective and the context of the study;
- The presentation of the main results of the study;
- The comparison of the results with the targets;
- The comments or recommendations of the Contractor.

The executive summary will be as concise as possible.

5.3.9.2 Main report

The main report is intended to be understandable by non specialist. It shall describe briefly the production facility, the objectives, the assumptions considered, the results of the different steps of the study and the main comments from the performer. The details of the assumptions, calculations, detailed tables, models, data shall be reported into appendices.

The main report shall be structured in accordance with the steps of the study:

- Objective / Consolidated SOW (summary if it is too big);
- Description of the functions and main hypothesis;
- Cause and effects analysis at system level;
- Modelling, results, explanations and comments,
- Conclusion including main comments and a summary of the main results.

5.3.9.3 Appendices

The appendices shall provide all details needed for the study to be checked and for any re- or further analysis.

They shall incorporate parts dedicated to :

- Consolidated SOW (if not in the main report);
- References used to perform the study;
- Assumptions register;
- Reliability data.
- Cause and effects analysis at item level (FMEA if any);
- Production Availability Diagram(s) achieved from the analysis of functions;
- Description of the modelling and calculation techniques, of the associated software package and of the evidence of its relevance for the study.
- Specific attention shall be paid to traceability of information. The origin of each piece of information shall be documented.



5.3.9.4 Production Availability Model

At the end of the study, the production availability model used for the calculations shall be provided in numerical version (input file).

5.3.10 Schedule

The planning of production availability studies shall comprise the following milestones:

- Start of the production availability study (Kick off meeting);
- SOW consolidation
- Issue of the system function analysis;
- Issue of the causes and effects analysis;
- Issue of the assumption sheets (pre-modelling meeting);
- Issue of the draft report (results presentation meeting);
- Issue of the final report.

Three meetings are mandatory:

- Kick off Meeting

The purpose of this review is to:

- Present the methodology described in this document,
- Present the case study,
- Identify the list of documents required to execute the study,
- Consolidate the SOW,
- Clarify the schedule,
- Remind participants of specific their roles and responsibilities.

- Pre-modelling validation meeting

This meeting is important to examine:

- All the assumptions to be used for the model,
- PAD,
- FMEA tables,
- The performance indicators to be calculated,
- And any sensitivity studies to be considered.

- Result presentation meeting



The objective of this meeting, organised on completion of revision 0 of the final study report, is to:

- Present the modelling results,
- Check whether targets have been achieved,
- Comment on the Contractor's recommendations regarding results on sensitivity studies,
- Assess the quality of the report and the work carried out.

In addition, it is strongly recommended to schedule intermediate review meetings between the preliminary and pre-modelling review meetings, in order to:

- Facilitate interactions among all parties and clarify any points that may not have been understood,
- Monitor study progress at regular intervals,
- Reduce the workload of the pre-modelling validation review by validating each step as it is completed,
- Maintain the study schedule.

Note: within the first steps the Contractor normally raises questions and problems. Then, enough calendar time shall be provided in the planning to allow the Company to answer.



Bibliography

ISO 14224	Petroleum, petrochemical and natural gas industries. Collection and exchange of reliability and maintenance data for equipment
IEC 60050-191	International Electro technical Vocabulary. Chapter 191: Dependability and quality of service
IEC 60812	Analysis techniques for system reliability. Failure mode and effects analysis (F.M.E.A.)



Appendix 1 Documents to be provided to the Contractor

Whenever available, following drawings and documents shall be provided by Company to Contractor.

Drawings

- Engineering diagrams, overall lay out;
- PFD's / P&IDs;
- ESD Cause and Effects charts;
- Fire and Gas Cause and Effects charts;
- Electrical one-line diagrams;
- Safety Logic diagram
- ...

Documents

- Process description;
- Operation philosophy;
- Maintenance philosophy;
- Safety philosophy;
- Equipment list;
- Planned maintenance / Inspection schedule.
- Production targets;
- ...



Appendix 2 Check list for restoration parameters

This check list is not intended to be exhaustive. It helps to identify which elements should be taken into consideration in the production availability study.

Events requiring an intervention as soon as possible such as:

- Loss of non redundant essential piece of equipment
- critical failures (leading immediately to a production loss)
- Unacceptable safety or environmental situation leading to a production shutdown
- ...

Events requiring an intervention which can be deferred and planned such as:

- Failure of an essential piece of equipment which benefits from a full (ex 2 x 100%) or partial (ex 3 x 33%) redundancy
- Failure inducing only a reduced production until repair (degraded failure)
- Failure inducing downgraded situation from safety or environment point of view and which needs special precautions to be taken
- ...

Events requiring an intervention which can be done at the occasion of a routine visit such as:

- Failure of non essential equipment
- Failure on equipment with high redundancy level
- ...

The restoration duration is understood as the total duration from the occurrence of the event up to the restoration of the normal condition. It includes:

- The detection time of the unplanned event
- The mobilisation time of the intervention crew (namely for events occurring at night and travels to go on location)
- The possible delay for initiating the related intervention (unavailability of the intervention means due to another repair in progress, Rig mobilisation, ROV mobilisation, travel to location, spare parts unavailability, wait on weather by example)
- The duration of the intervention itself up to restoration (active repair time)
- The possible production ramp from 0 up to nominal production when restarting
- The possible preservation operations
- ...

The intervention by itself may consist in:

- The repair/replacement of a faulty component
- The using of back-up or redundant equipment for restoring the normal production regime
- The modification of the production mode for ensuring a reduced production regime during the intervention (installation of a by-pass for example)



Appendix 2

- The re-start of the production after diagnostic (spurious shutdown due to a non-critical cause)
- ...

Depending on the system under study, attention must be paid to the management of spare parts, to the repair in several steps (temporary repair before the actual full repair) or delayed during the night, to the means mob / demob (Rig, ROV, repair specialist, etc.), to weather conditions (ex : no repair during Winter), to any delay for a correct diagnosis of the situation before going to an unmanned platform, ...

Attention shall also be paid to planned preventive maintenance

- by campaign for all equipments (facility shut down)
- on individual basis (an equipment at the time)
- masked or not behind another preventive maintenance on a bigger machine
- forbidden or not as long as a redundant part is under failure
- etc.