

**DEFINITIONS AND GUIDELINES
FOR
ESTIMATING AND CLASSIFYING
OIL AND GAS RESERVES**

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Comments should be directed as follows prior to March 15, 2002:

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PREAMBLE

The following definitions and guidelines have been prepared by the Standing Committee on Reserves Definitions of the Petroleum Society of the CIM after many years of consultations and deliberations. In the opinion of this Committee, these definitions and guidelines should be followed by qualified professionals when estimating and reporting reserves of oil and gas and related substances.

The accompanying definitions and guidelines are designed to assist both evaluators in making reserves estimates on a reasonably consistent basis, and users of their reports in understanding what such reports entail and, if necessary, in judging whether evaluators have followed generally accepted standards. The guidelines summarize: general requirements for classifying reserves, the procedures and methods for estimating reserves, confidence levels of individual entity and aggregate reserves estimates, and the validating and testing of reserves estimates.

1.0 DEFINITIONS OF RESERVES

1.1 INTRODUCTION

The determination of oil and gas reserves involves the preparation of estimates that have an inherent degree of associated uncertainty. Classifications of proved, probable and possible reserves have been established to reflect the level of these uncertainties and to provide an indication of the probability of recovery.

The estimation and classification of reserves requires the application of professional judgement combined with geological and engineering knowledge to assess whether or not specific reserves categorization criteria have been satisfied. Knowledge of concepts including uncertainty and risk, probability and statistics, and deterministic and probabilistic estimation methods is required to properly use and apply reserves definitions. These concepts are presented and discussed in greater detail within the guidelines that follow this section.

The following definitions apply to both estimates of individual reserves entities and the aggregate of reserves for multiple entities.

1.2 RESERVES CATEGORIES

Reserves are estimated remaining quantities of oil and natural gas and related substances anticipated to be recoverable from known accumulations, from a given date forward, based on:

- analysis of drilling, geological, geophysical and engineering data,
- the use of established technology, and
- specified economic conditions, which are generally accepted as being reasonable and shall be disclosed.

Reserves are classified according to the degree of certainty associated with the estimates.

1.2.1 *Proved reserves* are those reserves that can be estimated with a high degree of certainty to be recoverable. It is likely that the actual remaining quantities recovered will exceed the estimated proved reserves.

1.2.2 *Probable reserves* are those additional reserves that are less certain to be recovered than proved reserves. It is equally likely that the actual remaining quantities recovered will be greater or less than the sum of the estimated proved plus probable reserves.

1.2.3 *Possible reserves* are those additional reserves that are less certain to be recovered than probable reserves. It is unlikely that the actual remaining quantities recovered will exceed the sum of the estimated proved plus probable plus possible reserves.

Other criteria that must also be met for the categorization of reserves are provided in the accompanying General Guidelines for Application of Oil and Gas Reserves Definitions.

1.3 DEVELOPMENT AND PRODUCTION STATUS

Each of the reserves classifications (proved, probable and possible) may be divided into developed and undeveloped categories.

1.3.1 *Developed reserves* are those reserves that are expected to be recovered from existing wells and installed facilities or, if facilities have not been installed, that would involve a low expenditure (e.g. when compared to the cost of drilling a well) to put the reserves on production. The developed category may be subdivided into producing and nonproducing:

Developed producing reserves are those reserves that are expected to be recovered from completion intervals open at the time of the estimate. These reserves may be currently producing or, if shut-in, they must have previously been on production, and the date of resumption of production must be known with reasonable certainty.

Developed nonproducing reserves are those reserves that either have not been on production, or have previously been on production, but are shut-in, and the date of resumption of production is unknown.

1.3.2 *Undeveloped reserves* are those reserves expected to be recovered from known accumulations where a significant expenditure (e.g. when compared to the cost of drilling a well) is required to render them capable of production. They must fully meet the requirements of the reserves classification (proved, probable, possible) to which they are assigned.

In multi-well pools it may be appropriate to allocate total pool reserves between the developed and undeveloped categories or to subdivide the developed reserves for the pool between developed producing and developed non-producing. This allocation should be based on the estimator's assessment as to the reserves that will be recovered from specific wells, facilities and completion intervals in the pool and their respective development and production status.

1.4 LEVELS OF CERTAINTY FOR REPORTED RESERVES

The qualitative certainty levels contained in the definitions in Section 1.2 are applicable to individual *Reserves Entities*, which refers to the lowest level at which reserves calculations are performed, and to *Reported Reserves*, which refers to the highest level sum of individual entity estimates for which reserves estimates are presented. Reported Reserves should target the following levels of certainty under a specific set of economic conditions:

- At least a 90% probability that the quantities actually recovered will equal or exceed the estimated proved reserves.
- At least a 50% probability that the quantities actually recovered will equal or exceed the sum of the estimated proved plus probable reserves.
- At least a 10% probability that the quantities actually recovered will equal or exceed the sum of the estimated proved plus probable plus possible reserves.

A quantitative measure of the certainty levels pertaining to estimates prepared for the various reserves categories is desirable to provide a more clear understanding of the associated risks and uncertainties. However, the majority of reserves estimates will be prepared using deterministic methods that do not provide a quantitative measure of probability. In principle, there should be no difference between estimates prepared using probabilistic or deterministic methods.

Additional clarification of certainty levels associated with reserves estimates and the impact of aggregation is provided in Section 2.4 of the guidelines.

2.0 GENERAL GUIDELINES FOR APPLICATION OF OIL AND GAS RESERVES DEFINITIONS

2.1 INTRODUCTION

The following is a summary of fundamental guidelines that should be followed by reserves evaluators. These General Guidelines are intended to provide guidance that will aid in improving consistency in reserves reporting, but provide only a brief summary of the issues that may arise in applying the reserves definitions. Although more detailed guidelines are being developed, it must be recognized that reserves definitions and associated guidelines cannot address all possible scenarios nor can they remove the conditions of uncertainty that are inherent in all reserves estimates. It is the responsibility of the reserves evaluator to exercise sound judgement and apply these guidelines appropriately and objectively.

2.2 UNCERTAINTY IN RESERVES ESTIMATION

Reserves estimation has characteristics that are common to any measurement process that uses uncertain data. An understanding of statistical concepts and the associated terminology is essential to understanding the confidence associated with reserves definitions and classifications.

Uncertainty in a reserves estimate arises from a combination of error and bias:

- Error is inherent in the data that are used to estimate reserves. Note that the term “Error” refers to limitations in the input data, not to a mistake in interpretation or application of the data. The procedures and concepts dealing with error lie within the realm of statistics and are well established.
- Bias, which is a predisposition of the evaluator, has various sources that are not necessarily conscious or intentional.

In the absence of bias, different qualified evaluators using the same information at the same time will produce reserves estimates that will not be materially different, particularly for the aggregate of a large number of estimates. The range within which these estimates should reasonably fall depends on the quantity and quality of the basic information, and the extent of analysis of the data.

2.3 DETERMINISTIC AND PROBABILISTIC METHODS

Reserves estimates may be prepared using either deterministic or probabilistic methods.

2.3.1 Deterministic Method

The deterministic approach, which is the one most commonly employed worldwide, involves the selection of a single value for each parameter in the reserves calculation. The discrete value for each parameter is selected based on the estimator’s determination of the value that is most appropriate for the corresponding reserves category.

2.3.2 Probabilistic Method

Probabilistic analysis involves describing the full range of possible values for each unknown parameter. This approach typically consists of employing computer software to perform repetitive calculations (e.g. “Monte Carlo Simulation”) to generate the full range of possible outcomes and their associated probability of occurrence.

2.3.3 Comparison of Deterministic and Probabilistic Estimates

Deterministic and probabilistic methods are not distinct and separate. A deterministic estimate is a single value within a range of outcomes that could be derived by a probabilistic analysis. Ideally, there should be no difference between Reported Reserves estimates prepared using deterministic and probabilistic methods.

2.3.4 Application of Guidelines to the Probabilistic Method

The following guidelines include criteria that provide specific limits to parameters for proved reserves estimates. For example, volumetric estimates are restricted by the lowest known hydrocarbon (LKH). Inclusion of such specific limits may conflict with standard probabilistic procedures, which require that input parameters honour the range of potential values.

Nonetheless, it is required that the guidelines be met regardless of analysis method. Accordingly, when probabilistic methods are used, constraints on input parameters may be required in certain instances. Alternatively, a deterministic check may be made in such instances to ensure that aggregate estimates prepared using probabilistic methods do not exceed those prepared using a deterministic approach including all appropriate constraints.

2.4 AGGREGATION OF RESERVES ESTIMATES

Reported Reserves are typically comprised of the aggregate of estimates prepared for a number of individual wells, reservoirs and/or properties/fields.

When deterministic methods are used, Reported Reserves will be the simple arithmetic sum of all estimates within each reserves category. Evaluators and users of reserves information must understand the effect of summation on the probabilities of estimates. The probability associated with the arithmetic sum for a number of individual independent estimates is different from that of the individual estimates. Arithmetic summation of independent high probability estimates will result in a total with a higher probability; arithmetic summation of low probability estimates will yield a total with a lower probability.

As the definitions and guidelines require a conservative approach in the estimation of proved reserves, the minimum probability target for proved Reported Reserves will be satisfied with a deterministic approach as long as there are enough independent entity estimates in the aggregate. Where a very small number of entities dominate in the Reported Reserves, a specific effort to meet the probability criteria may be required in preparing deterministic estimates of proved reserves. Since

proved plus probable reserves prepared by deterministic methods will approximate mean values, the probability associated with the estimates will essentially be unaffected by aggregation.

When probabilistic techniques are used in reserves estimation, aggregation is typically performed within the probabilistic model. It is critical that such models appropriately include all dependencies between variables and components within the aggregation. Where dependencies and specific criteria contained in the guidelines have been treated appropriately, reserves for the various categories would be defined by the minimum probability requirements contained in Section 1.4, subject to the considerations provided in the following paragraphs.

Reported Reserves for a company will typically not be the aggregate results from a single probabilistic model since reserves estimates are used for a variety of purposes including planning, reserves reconciliation, accounting, securities disclosure and asset transactions. These uses will generally necessitate tabulations of reserves estimates at lower aggregation levels than the total Reported Reserves. For these reasons, and due to the lack of general acceptance of probabilistic aggregation up to the company level, reserves should generally not be aggregated probabilistically beyond the field (or property) level.

Statistical aggregation of a tabulation of values, which does not result in a straightforward arithmetic addition, is not accepted for most reporting purposes. Consequently, discrete estimates for each reserves category resulting from separate probabilistic analyses, which may, as appropriate, include aggregation up to the field (or property) level, should be summed arithmetically. As a result, Reported Reserves will meet the probability requirements in Section 1.4 regardless of dependencies between separate probabilistic analyses and may be summed with deterministic estimates within each reserves category.

It is recognized that the foregoing approach imposes an additional measure of conservatism when proved reserves are derived from a number of independent probabilistic analyses since the sum of independent 90 percent probability estimates has an associated probability of greater than 90 percent. Nonetheless, this is considered to be an acceptable consequence given the need for a discrete accounting of component proved estimates.

Conversely, this approach will cause the sum of proved plus probable plus possible reserves derived from a number of probabilistic analyses to fail to meet the 10 percent minimum probability requirement. Given the limited application for proved plus probable plus possible Reported Reserves, this is also considered to be an acceptable consequence.

2.5 GENERAL REQUIREMENTS FOR CLASSIFICATION OF RESERVES

The following general conditions must be satisfied in the estimation and classification of reserves:

2.5.1 Drilling Requirements

Proved, probable or possible reserves may be assigned only to known accumulations that have been penetrated by a wellbore. Potential hydrocarbon accumulations that have not been penetrated by a wellbore may be classified as Prospective Resources.

2.5.2 Testing Requirements

Confirmation of commercial productivity of an accumulation by production or a formation test is required for classification of reserves as proved. In the absence of production or formation testing, probable and/or possible reserves may be assigned to an accumulation on the basis of well logs and/or core analysis which indicate that the zone is hydrocarbon bearing and is analogous to other reservoirs in the immediate area that have demonstrated commercial productivity by actual production or formation testing.

2.5.3 Economic Requirements

Proved, probable or possible reserves may be assigned only to those volumes which are economically recoverable. The fiscal conditions under which reserves estimates are prepared should generally be those which are considered to be a reasonable outlook on the future. If required by securities regulators or other agencies, constant or other prices and costs also may be used. In any event, the fiscal assumptions used in the preparation of reserves estimates must be disclosed.

Undeveloped recoverable volumes must have a sufficient return on investment to justify the associated capital expenditure in order to be classified as reserves as opposed to Contingent Resources.

2.5.4 Regulatory Considerations

In general, proved, probable or possible reserves may be assigned only in instances where production or development of those reserves is not prohibited by governmental regulation. This provision would, for instance, preclude the assignment of reserves in designated environmentally sensitive areas. Reserves may be assigned in instances where regulatory restraints may be removed subject to satisfaction of minor conditions. In such cases, the classification of reserves as proved, probable or possible should be made with consideration given to the risk associated with project approval.

2.6 PROCEDURES FOR ESTIMATION AND CLASSIFICATION OF RESERVES

The process of reserves estimation falls into three broad categories: volumetric, material balance and decline analysis. Selection of the most appropriate reserves estimation procedures depends on the information that is available. Generally, the range of uncertainty associated with an estimate decreases and confidence level increases as more information becomes available and when the estimate is supported by more than one estimation method. Regardless of the estimation method(s) employed, the resulting reserves estimate should meet the certainty criteria in Definitions of Reserves.

2.6.1 Volumetric Methods

Volumetric methods involve the calculation of reservoir rock volume, the hydrocarbons in place in that rock volume and the estimation of the portion of the hydrocarbons in place that ultimately will be recovered. For various reservoir types at varied stages of development and depletion, the key unknown in volumetric reserves determinations may be rock volume, porosity, fluid saturation or

recovery factor. Important considerations affecting a volumetric reserves estimate are outlined below:

- Rock volume – may simply be determined as the product of a single well drainage area and wellbore net pay or by more complex geological mapping. Estimates must take into account geological characteristics, reservoir fluid properties and the drainage area that could be expected for the well or wells. Consideration must be given to any limitations indicated by geological, geophysical data or interpretations as well as pressure depletion or boundary conditions exhibited by test data.
 - # Elevation of Fluid Contacts - In the absence of data that clearly defines fluid contacts, the structural interval for volumetric calculations of proved reserves should be restricted by the lowest known structural elevation of occurrence of hydrocarbons (LKH) as defined by well logs, core analyses or formation testing.
- Porosity and fluid saturation and other reservoir parameters – determined from logs and core and well test data.
- Recovery factor - based on analysis of production behavior from the subject reservoir, by analogy with other producing reservoirs and/or by engineering analysis. In estimating recovery factors, the evaluator must consider factors that influence recoveries such as rock and fluid properties, hydrocarbons-in-place, drilling density, future changes in operating conditions, depletion mechanisms and economic factors.

2.6.2 Material Balance Methods

Material balance methods of reserves estimation involve the analysis of pressure behavior as reservoir fluids are withdrawn, and generally result in more reliable reserves estimates than volumetric estimates. Reserves may be based on material balance calculations when sufficient production and pressure data is available. Confident application of material balance methods requires knowledge of rock and fluid properties, aquifer characteristics and accurate average reservoir pressures. In complex situations, such as those involving water influx, multi-phase behavior, multi-layered or low permeability reservoirs, material balance estimates alone may provide erroneous results.

Computer reservoir modeling can be considered a sophisticated form of material balance analysis. While modeling can be a reliable predictor of reservoir behavior, the input rock properties, reservoir geometry and fluid properties are critical. Evaluators must be aware of the limitations of predictive models when using these results for reserves estimation.

The portion of reserves estimated as proved, probable or possible should reflect the quantity and quality of the available data and the confidence in the associated estimate.

2.6.3 Production Decline Methods

Production decline analysis methods of reserves estimation involve the analysis of production behavior as reservoir fluids are withdrawn. Confident application of decline analysis methods requires a sufficient period of stable operating conditions after the wells in a reservoir have established drainage areas. In estimating reserves, evaluators must take into consideration factors affecting production decline behavior, such as reservoir rock and fluid properties, transient versus stabilized flow, changes in operating conditions (both past and future) and depletion mechanism.

Reserves may be assigned based on decline analysis when sufficient production data is available. The decline relationship used in projecting production should be supported by all available data.

The portion of reserves estimated as proved, probable or possible should reflect the confidence in the associated estimate.

2.6.4 Reserves Related to Future Drilling and Planned Enhanced Recovery Projects

The foregoing reserves estimation methodologies are applicable to recoveries from existing wells and enhanced recovery projects that have been demonstrated to be economically and technically successful in the subject reservoir by actual performance or a successful pilot. The following criteria should be considered when estimating incremental reserves associated with development drilling or implementation of enhanced recovery projects. In all instances, the probability of recovery of the associated reserves must meet the certainty criteria contained in Definitions of Reserves.

Additional Reserves Related to Future Drilling

Additional reserves associated with future drilling in known accumulations may be assigned where economics support and regulations do not prohibit the drilling of the location.

Aside from the criteria stipulated in Definitions of Reserves, factors to be considered in classifying reserves estimates associated with future drilling as proved, probable or possible include:

- Whether the proposed location directly offsets existing wells or acreage with proved or probable reserves assigned, and
- The expected degree of geological continuity within the reservoir unit containing the reserves, and
- The likelihood that the location will be drilled.

In addition, where infill wells will be drilled and placed on production, the estimator must quantify well interference effects, that portion of recovery which represents accelerated production of developed reserves, and that portion which represents incremental recovery beyond those reserves recognized for the existing reservoir development.

Reserves Related to Planned Enhanced Recovery Projects:

Reserves that can be economically recovered through the future application of an established enhanced recovery method may be classified as follows:

Proved reserves may be assigned to planned enhanced recovery projects when the following criteria are met:

- Repeated commercial success of the enhanced recovery process has been demonstrated in reservoirs in the area with analogous rock and fluid properties,
- The project is highly likely to be carried out in the near future. This may be demonstrated by factors such as the commitment of project funding, and
- Where required, either regulatory approvals have been obtained, or no regulatory impediments are expected, as clearly demonstrated by the approval of analogous projects.

Probable reserves may be assigned when a planned enhanced recovery project does not meet the requirements for classification as proved, however, the following criteria are met:

- The project can be shown to be practically and technically reasonable, and
- Commercial success of the enhanced recovery process has been demonstrated in reservoirs with analogous rock and fluid properties, and
- It is reasonably certain that the project will be implemented.

Possible reserves may be assigned when a planned enhanced recovery project does not meet the requirements for classification as proved or probable, however, the following criteria are met:

- The project can be shown to be practically and technically reasonable, and
- Commercial success of the enhanced recovery process has been demonstrated in reservoirs with analogous rock and fluid properties but there remains some doubt that the process will be successful in the subject reservoir.

2.7 VERIFICATION OF RESERVES ESTIMATES

A practical method of verifying that reserves estimates meet the definitions and guidelines is through periodic reserves reconciliation of both entity and aggregate estimates. The tests described below should be applied to the same entities or groups of entities over time, excluding revisions due to differing economic assumptions:

- Revisions to proved reserves estimates should generally be positive as new information becomes available.
- Revisions to proved plus probable reserves estimates should generally be neutral as new information becomes available.
- Revisions to proved plus probable plus possible estimates should generally be negative as new information becomes available.

These tests can be used to monitor whether procedures and practices employed are achieving results consistent with certainty criteria contained in Definitions of Reserves. In the event that the above tests are not satisfied on a consistent basis, appropriate adjustments should be made to evaluation procedures and practices.