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# Natural gas — Upstream area — Allocation of gas and condensate

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TECHNICAL REPORT

# ISO/TR 26762

First edition
2008-07-15

# Natural gas — Upstream area — Allocation of gas and condensate

*Gaz naturel — Zone amont — Allocation du gaz et du condensat*

Reference number
ISO/TR 26762:2008(E)

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## Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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## Introduction

Hydrocarbon gas and condensate from onshore or offshore concessions is often transported by shared pipelines to shared main treatment facilities. The concessions are often owned by or licensed to a number of oil companies. At the main treatment facilities, the gas and condensate are processed to sales specifications. The gas is sold to shippers in terms of standard volume (standard cubic metres) or combustion energy (joules), and the condensate is sold in terms of standard volume (standard cubic metres) or mass (kilograms or tonnes). All the gas and condensate sold at the main treatment facility and the associated money should be allocated back to the individual concessions and, ultimately, to the individual reservoirs or wells, as illustrated in Figure 1.

When gas from two or more entry sources (e.g. two or more different companies) is commingled and processed in a common pipeline and terminal system and the sources have different ownership and/or operate under different tax regimes, then a gas allocation system is required. It is necessary that the allocation system provide a fair, equitable and auditable means of sharing out the products from the system to the entry sources and to the associated partners, recognizing the specific delivery requirements of each participant.

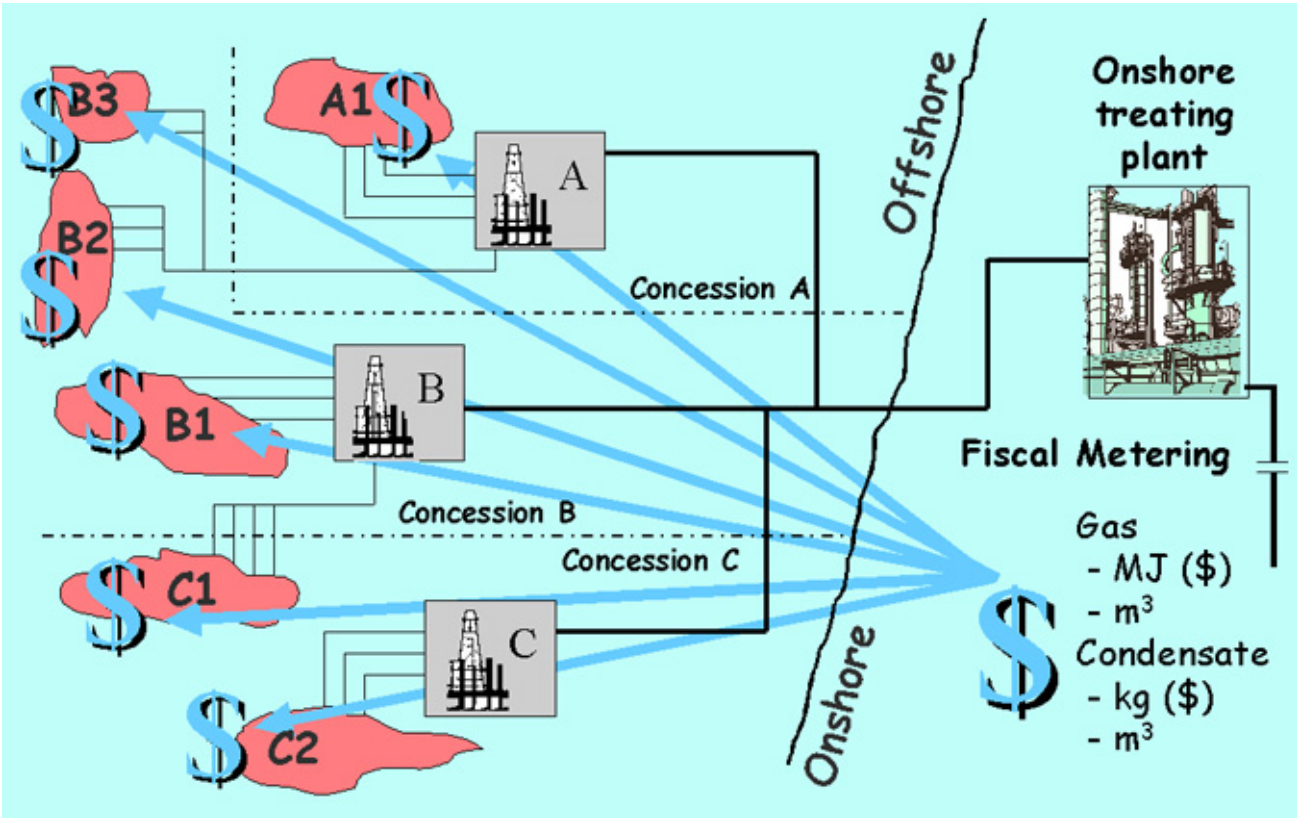


**Figure 1 — Offshore gas distributions**


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# Natural gas — Upstream area — Allocation of gas and condensate

## 1 Scope

This Technical Report describes the production measurements, in terms of both hardware and procedures, that can be used to allocate the gas and condensate back to the individual concessions, reservoirs and wells in a fair and equitable way. The objective is to give an approach that is recognized to be current best practice and that has a wide support in the oil and gas industry.

## 2 Normative references

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

ISO 5168, *Measurement of fluid flow — Procedures for the evaluation of uncertainties*

ISO 6974 (all parts), *Natural gas — Determination of composition with defined uncertainty by gas chromatography*

ISO 6975, *Natural gas — Extended analysis — Gas-chromatographic method*

ISO 6976:1995, *Natural gas — Calculation of calorific values, density, relative density and Wobbe index from composition*

ISO 9951, *Measurement of gas flow in closed conduits — Turbine meters*

ISO 10715, *Natural gas — Sampling guidelines*

## 3 Economic aspects

### 3.1 Overview

#### 3.1.1 General

Production measurements in the upstream area, whether single-phase or multiphase, have an economic impact on the business. The implementation of production measurements costs money, but in return delivers data that can be used in decision-making processes and in measuring the economic returns. Generally, it is necessary to give the three issues described in 3.1.2 to 3.1.4 proper consideration to implement a cost-effective measurement and allocation system.

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### 3.1.2 Value of information

The decision-making processes that use production measurement information are those associated with production optimization or reservoir modelling. Figure 2 indicates, schematically, the effect of measurement accuracy on the uncertainty band of the ultimate recovery from a concession (i.e. total production over field life). With poor accuracy in the measurements, the uncertainty band and associated risk exposure stay relatively large. With better and more accurate measurements, the uncertainty band and associated financial risk are reduced. The assessment of the value of information is the most difficult part of designing an allocation system and it is probably for that reason that it is rarely done properly, if at all. As an example, the difference between production allocation (i.e. allocation of fluids from a production facility to the individual wells) and sales allocation (i.e. allocation of products in a common pipeline) can be mentioned. In the sales allocation, it can be directly calculated what the relation is between uncertainties in fluid flow measurement and risk in money flow between the companies involved. In the production allocation, often within one single company, this is less obvious as complex reservoir modelling and petroleum economics are involved. This is often why, in general, the requirements for sales allocation are higher than the requirements for production allocation.

### 3.1.3 Hardware costs

Capital expenditures for production facilities, test separators, test lines, multiphase flow meters, etc. can all be assessed relatively easily. It should also be noted that the higher the accuracy requirement for a particular meter, the more expensive the meter hardware. This is the easiest part in the total cost estimate.

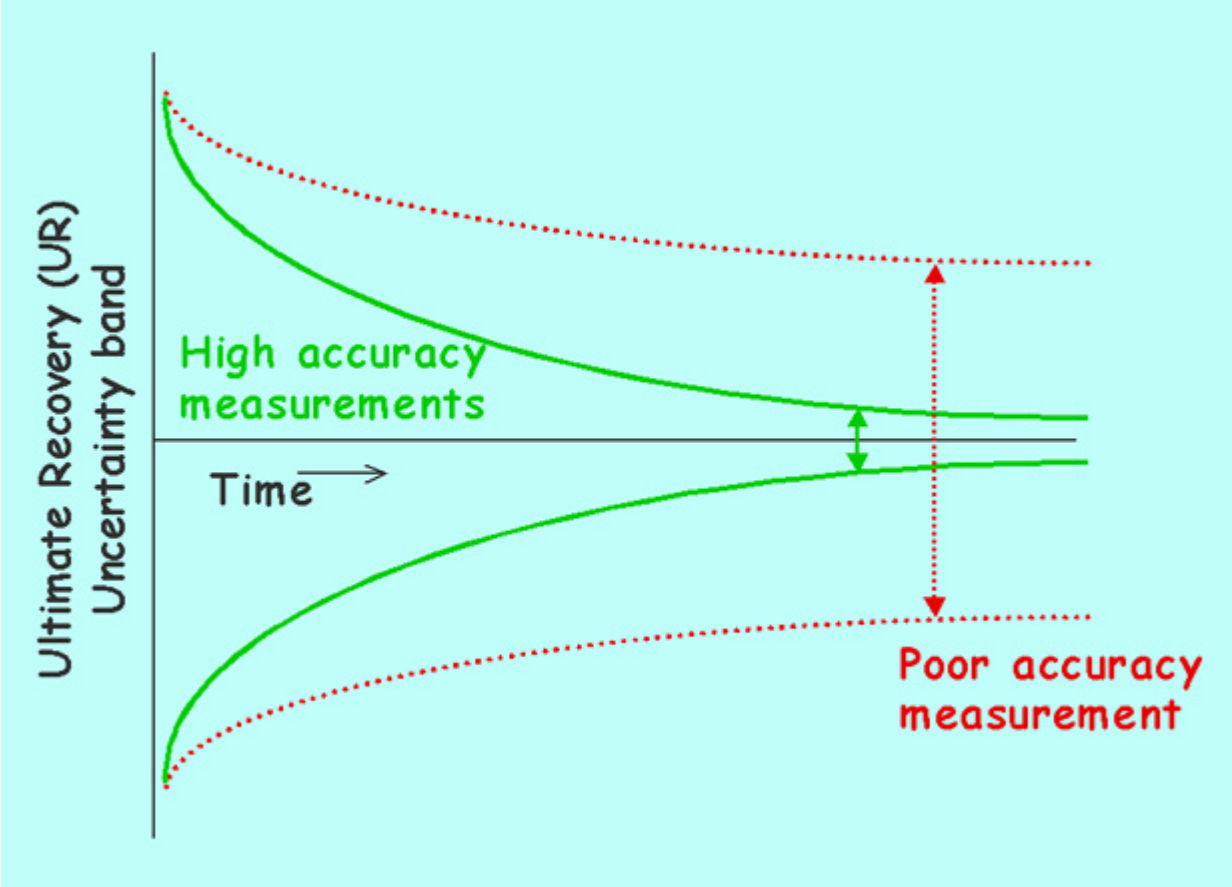


**Figure 2 — Cost treatment of metering**


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#### 3.1.4 Operating costs

Preparation and implementation of procedures and guidelines to keep the production measurement equipment in good shape (maintenance, verification and calibration) and to ensure that readings are reliable and within the original specifications require sufficient and consistent dedication during the operations phase. These costs are often underestimated, especially with new technologies such as multiphase or wet-gas flow metering.

### 3.2 Uncertainty and costs

With respect to uncertainty and costs, two extreme cases are considered.

— One extreme is a production system with very high accuracy in production measurements. Due to increased hardware costs and intensive operator involvement, the project and operating costs are higher, but with more and better information, better reservoir management and production optimization can be carried out. Consequently, the uncertainty band in the ultimate recovery decreases, giving a lower spread in project and operating risks (see Figure 2). Realizing that the value of the oil in the ground is limited, we can also conclude that at a certain cost level the development becomes economically unattractive.

— The other extreme is a poor accuracy in the production measurements or production is not measured at all. Poor reservoir management, sub-optimal production optimization and potential loss of revenue are the result. Consequently, the uncertainty band in the ultimate recovery stays large. The development can unwittingly become unattractive from an economic and risk point of view.

Somewhere between the above two extremes there is an optimum acceptable uncertainty, with the associated costs for the measurement and allocation processes. This is illustrated in Figure 3, in which costs (in arbitrary units) are plotted against acceptable uncertainty. This optimum can well be different for each individual hydrocarbon development. It can well be the case that, for a particular development, an accuracy of 10 % in gas flow rate is sufficient while in another development a 2 % accuracy is required.

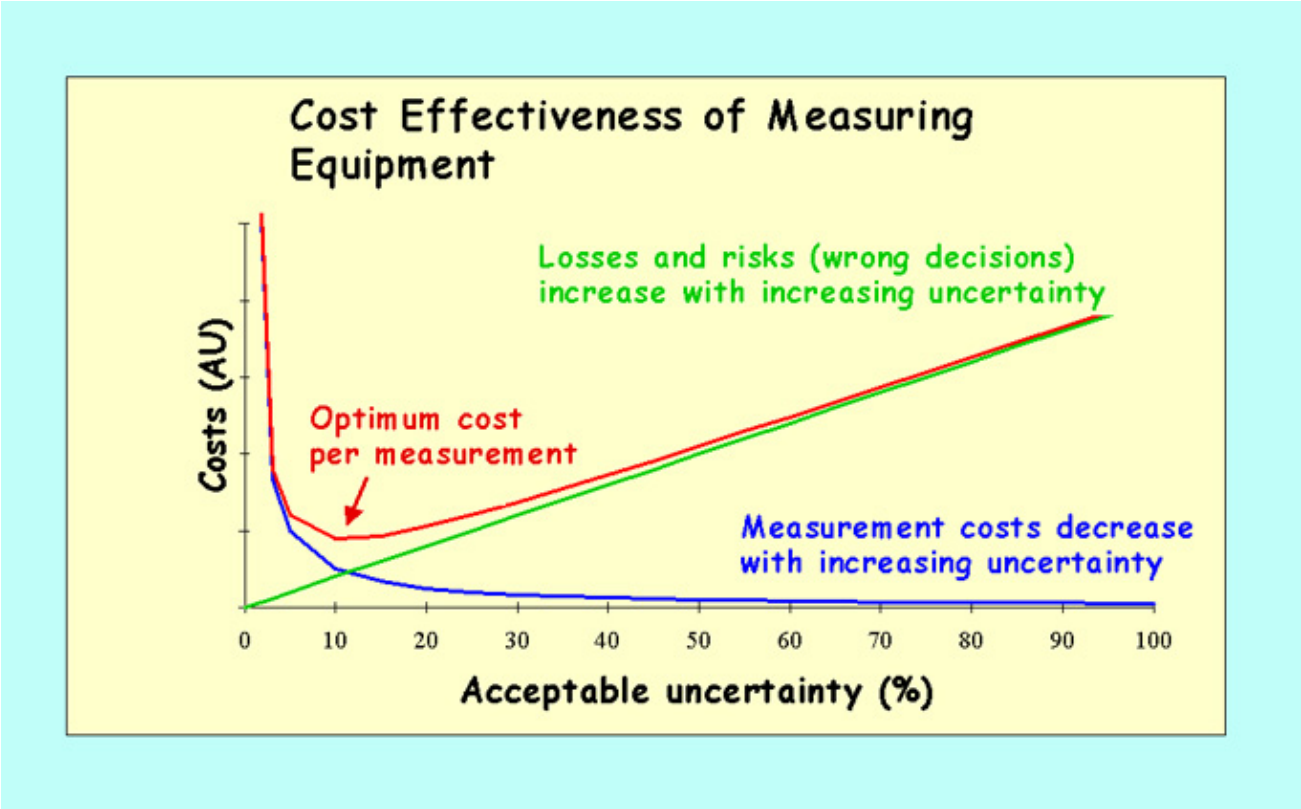


**Figure 3 — Costs related to uncertainty**

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## 3.3 Allocation system overview

It is not unusual to take between one and two years to negotiate all the terms of a gas and condensate allocation agreement. A wide array of skills is required to understand the diverse topics in the development of an allocation system. To successfully conclude an agreement, it is good practice to form a team with expertise in the following:

— commercial negotiation;

— gas legislation;

— gas marketing;

— measurement and allocation;

— production operation;

— IT.

Besides the preparation of the commercial agreement, it is necessary to develop the business processes to manage the day-to-day operation of the agreement. It is imperative to establish responsibilities and ownership for the following:

— hydrocarbon stream meter data;

— hydrocarbon stream analysis;

— production forecast information;

— allocation system operation.

Development of the business processes requires a review of almost all departments within a gas production organization to ensure that the workload associated with the operation of the allocation system can be performed adequately and to identify whether additional personnel or external resources are required.

### 3.3.1 Overall scope of an allocation agreement

Figure 4 gives an overview of the major issues that feature in a gas and condensate allocation agreement. These issues are discussed separately in the following subclauses. One party or department should be charged with overall responsibility for producing the agreement, but the party or department may vary from company to company. It is of utmost importance that all parties or departments involved in the agreement ensure that the issues affecting them are properly and adequately dealt with in the agreement.

### 3.3.2 Reservoir performance

Reservoir performance data are required to assist in the forecasting of production to the operator of the gas treatment facilities. Long-term forecasts issued are likely based partly on the technical view of the reservoir potential and partly on the commercial view of possible future business. Shorter-term forecasts likely have a more technical focus and are likely developed in conjunction with operations staff to incorporate planned shutdowns, etc.

In addition, reservoir engineers provide an overview of the differences in composition of the fluids from the reservoirs covered by the allocation agreement. Reservoir engineering departments are normally responsible for the initial sampling and associated fluid analyses. Specific analytical requirements regarding gas quality should be discussed with the reservoir engineering departments to ensure provision of the appropriate data.


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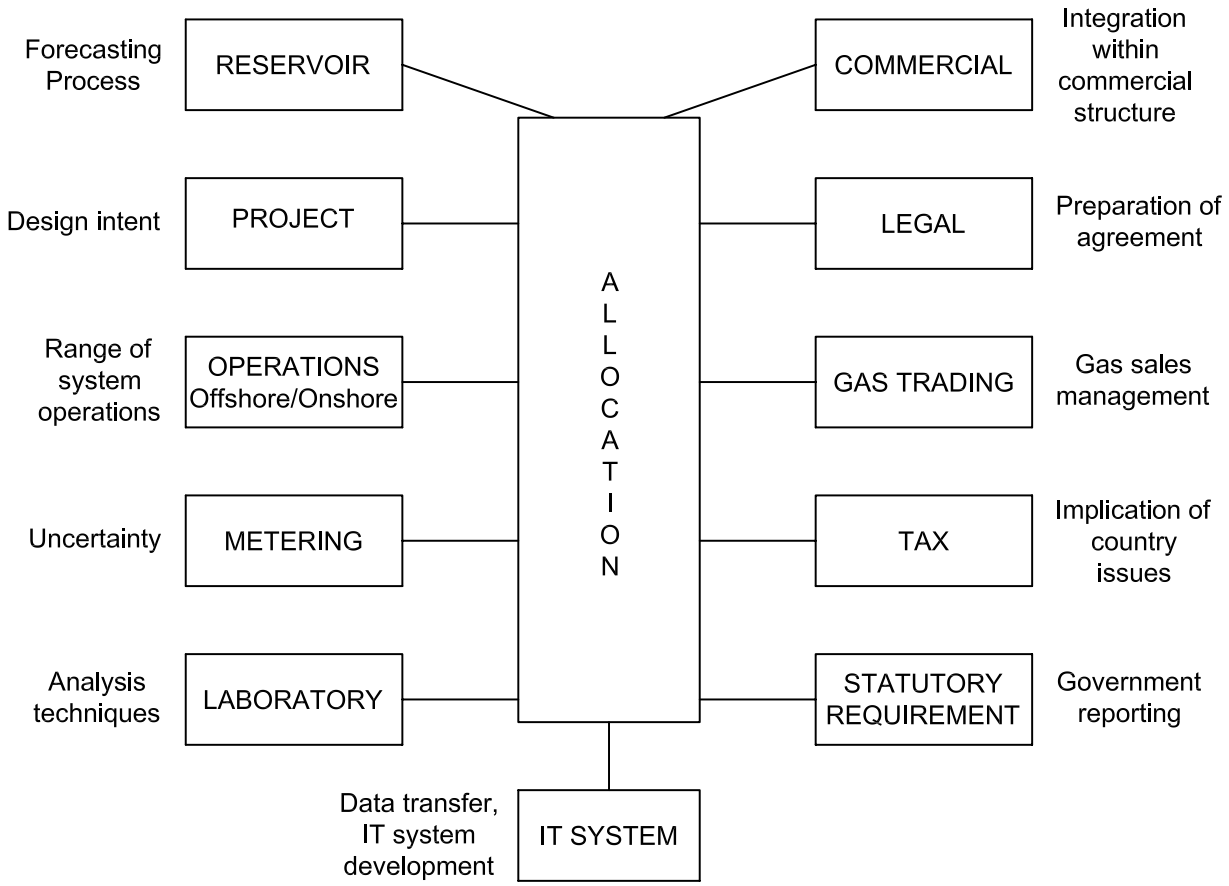


**Figure 4 — Issues that feature in a gas and condensate allocation agreement**

### 3.3.3 Project specifications

Discussions are required with the project team to ensure that

— the necessary metering devices are provided to the specified uncertainty levels,

— sampling systems are installed to obtain adequately representative gas and condensate samples,

— acceptable and appropriate analyses of the gas and condensate samples are performed,

— the required data are captured and transferred to a central IT system and an adequate production-measurement management system is in place (see ISO 10012).

Parties involved in these discussions include the metering and IT departments and, where appropriate, the operator of the gas treatment facilities.

### 3.3.4 Operations/gas-trading and coordinating group

A review of the allocation agreement should be made with the parties involved with the agreement to ensure that they understand and appreciate the implications of the agreement on their day-to-day duties and to ensure they have the opportunity to feed back potential problems or conflicts with existing agreements and associated operations.

The gas-trading group should ensure that the allocation agreement complies with gas marketing and reporting requirements for entry to the gas distribution network from the gas treatment facilities.

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### 3.3.5 Metering requirements

Appropriately qualified and experienced metering engineers should be responsible for specifying and selecting the individual meters and associated equipment. When operations start, they should be responsible for the validation of metering data.

The validated meter data should be made available to the hydrocarbon accountants to run the allocation calculations and generate the allocation reports. It is necessary that the validation process for the metered data be performed independently of the allocation calculations. There is a tendency to use allocation processes as a check on the quality of the metering process. Balance factors or reconciliation factors can be used, with care, to highlight possible metering problems. Ideally, limits to these factors should be set based on sensitivity studies with the intrinsic uncertainties of the individual meters as input.

### 3.3.6 Laboratory requirements

Pressurized samples of gas and condensate are sent to a laboratory that has been selected for the shared pipeline system. The selected laboratory should have appropriate, acceptable accreditation.

Procedures should be developed for

— control and maintenance of the sample vessels,

— transportation of pressurized sample vessels between the production facilities and the laboratory,

— receipt and validation of the sample fluids,

— conducting and reporting of the analyses.

### 3.3.7 Commercial issues

The commercial group should review the allocation agreement for consistency with other agreements.

### 3.3.8 Legal issues

In general, the allocation agreement is written by the responsible allocation personnel, with the metering section of the agreement produced by the metering engineer and the commercial issues dealt with by the commercial department. A review by the legal department is required to check for consistency with other agreements and that the liability clauses are appropriate and acceptable.

### 3.3.9 Tax issues

In some jurisdictions, the tax and royalty implications associated with a field and/or a party can have the most dominant impact on the revenue from an allocation system. A review is essential at the early stages of a development to ascertain any tax implications and incorporate the appropriate mechanisms within the allocation procedure.

Customs duties can be particularly relevant when gas and condensate from a development is produced into a shared pipeline in one country and entitlement to blended gas and condensate is received in another country.

### 3.3.10 Statutory requirements

It is essential at an early stage in a development to undertake a review of the statutory requirements and seek the necessary approvals from the appropriate governing bodies.


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#### 3.3.11 IT systems

The development of an IT system to perform the allocation procedure can take a significant period of time to implement, test and hand over to the responsible department. Because of tight development deadlines, it can be necessary to start the IT system design before the commercial agreement is finalized and strict project management is required to control the IT vendor and minimize change requests.

The software should be developed in a structure suitable to the application, with particular attention paid to the ability to modify/expand the system whilst maintaining the capability to revert to rerunning a pre-modification allocation.

#### 3.3.12 Overall metering system

The entire process of metering and allocation (the metering hardware, the algorithms used, the data transmission and storage systems) should be covered by an adequate management process (see ISO 10012).

# 4 Allocation from different viewpoints and terminology

## 4.1 Physical system

This Technical Report is intended for use in the measurement and allocation of natural gas and condensate in multi-user pipeline transportation systems.

Such a system is typically comprised of production facilities, pipelines, reception facilities, processing facilities and sales points. Each of these elements can be represented in the allocation system described in 4.2 to 4.5 (see Figure 5 for an example of a typical system).

## 4.2 Gas/condensate system overview

### 4.2.1 System diagram

The physical system can be represented as a single-line nodal diagram, representing all the (production) sources, sinks (gas used for fuel, flare, vent, gas lift, injection gas, etc.), as well as flow paths of product. See Figure 5.

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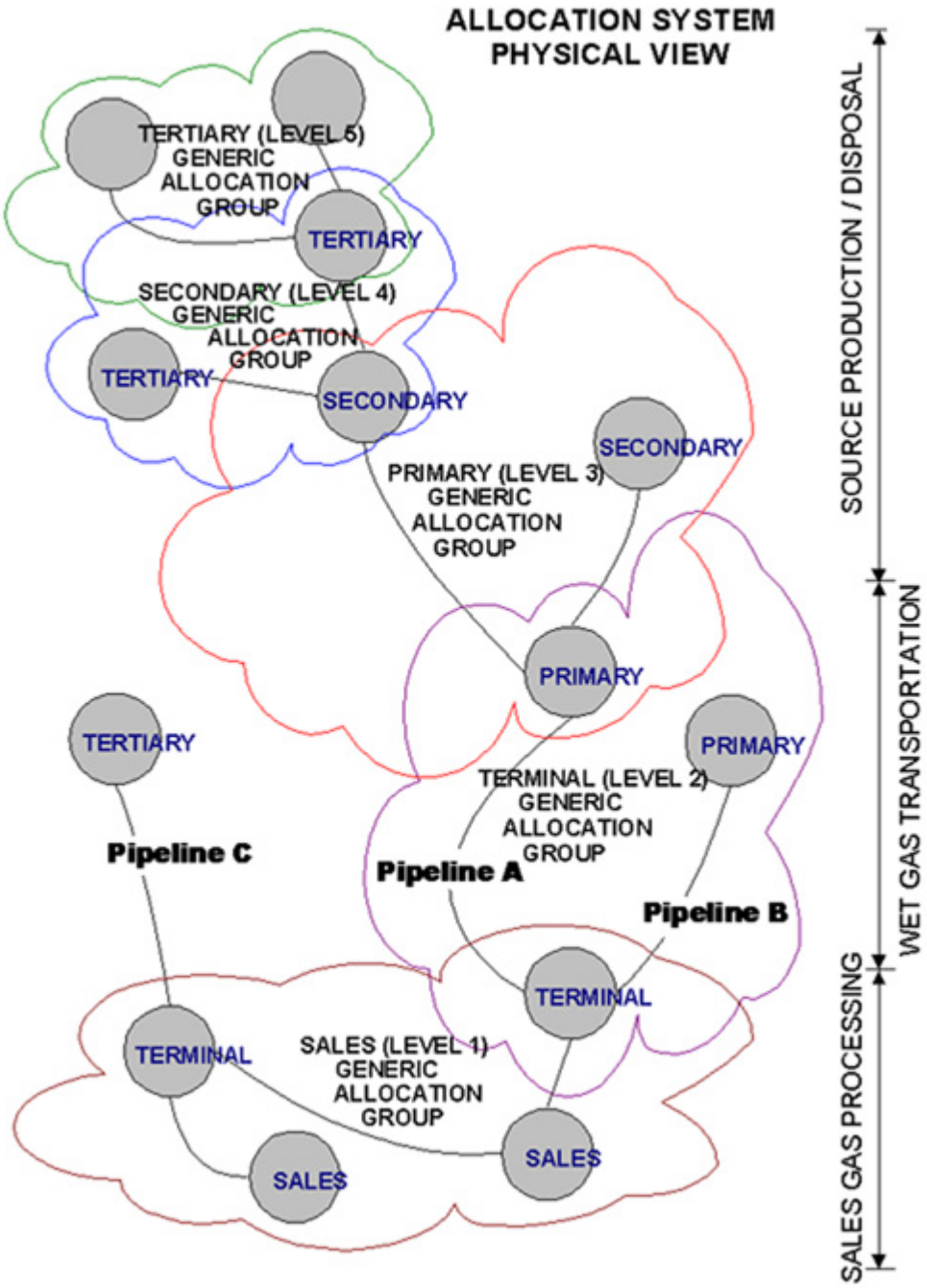


**Figure 5 — Physical system**


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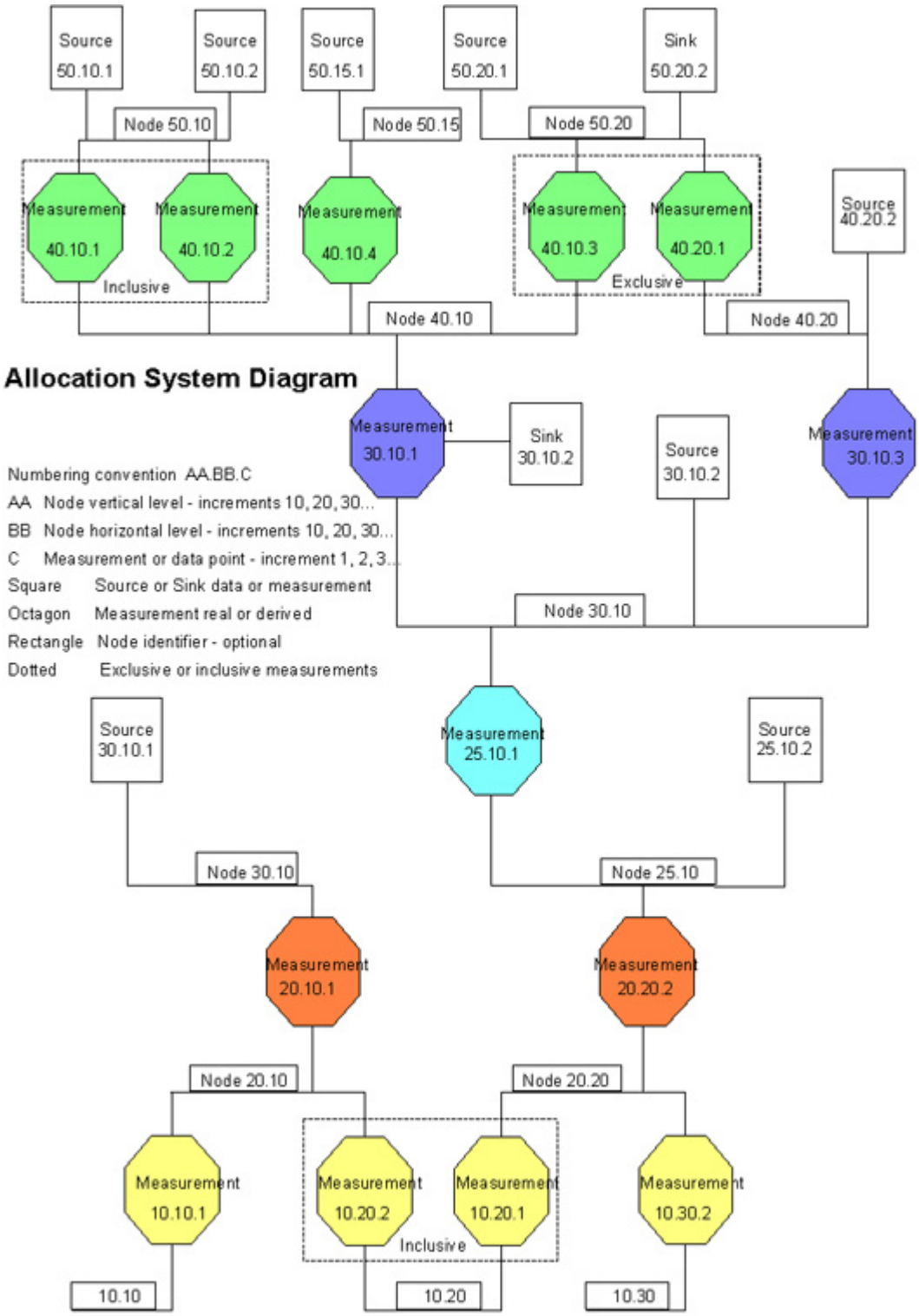


**Figure 6 — Allocation system diagram**

A supporting table (Table 1) developed from the system diagram (see Figure 6) describes what each node in the system represents, what the name of the producing field asset can be, the equity ownership interests, etc. It can further describe any product processing, calculations, simulations, yield factors, etc., as well as the allocation protocol for the node concerned.

The system description table (diagram) can look something like Table 1:

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**Table 1 — System description table**

| Node no. | Process function | Equity ownership | Allocation protocol/function | — | Comments |
|---|---|---|---|---|---|

Other information can be provided, such as the following:

a) source: Any product feed entering a system node; this is generally a production stream coming from one or more wells or production facilities.

b) sink: Any product feed leaving a system node; this is generally gas and condensate sales streams but also water disposal streams, flare gas flows, blow-off gas, etc.

c) node: Any point in the system defined for the purpose of quantifying the quantity and quality of product passing through it.

d) commingling: Combination of product streams from two or more wells or production facilities into a common separator, pipeline or tank.

e) reconciliation: The process of dealing with any quantity imbalance between sources and sinks; possible phase changes between the gas and condensate phase can be taken into account as well. Reconciliation can take place at any node in the system and is usually done at agreed periodic intervals.

### 4.2.2 Allocation process

This is the process by which a quantity of hydrocarbon gas and hydrocarbon condensate, measured at a sink (e.g. sales point) is allocated to one or more contributing sources. (See Figure 7 for an example of a typical allocation process flow chart.)


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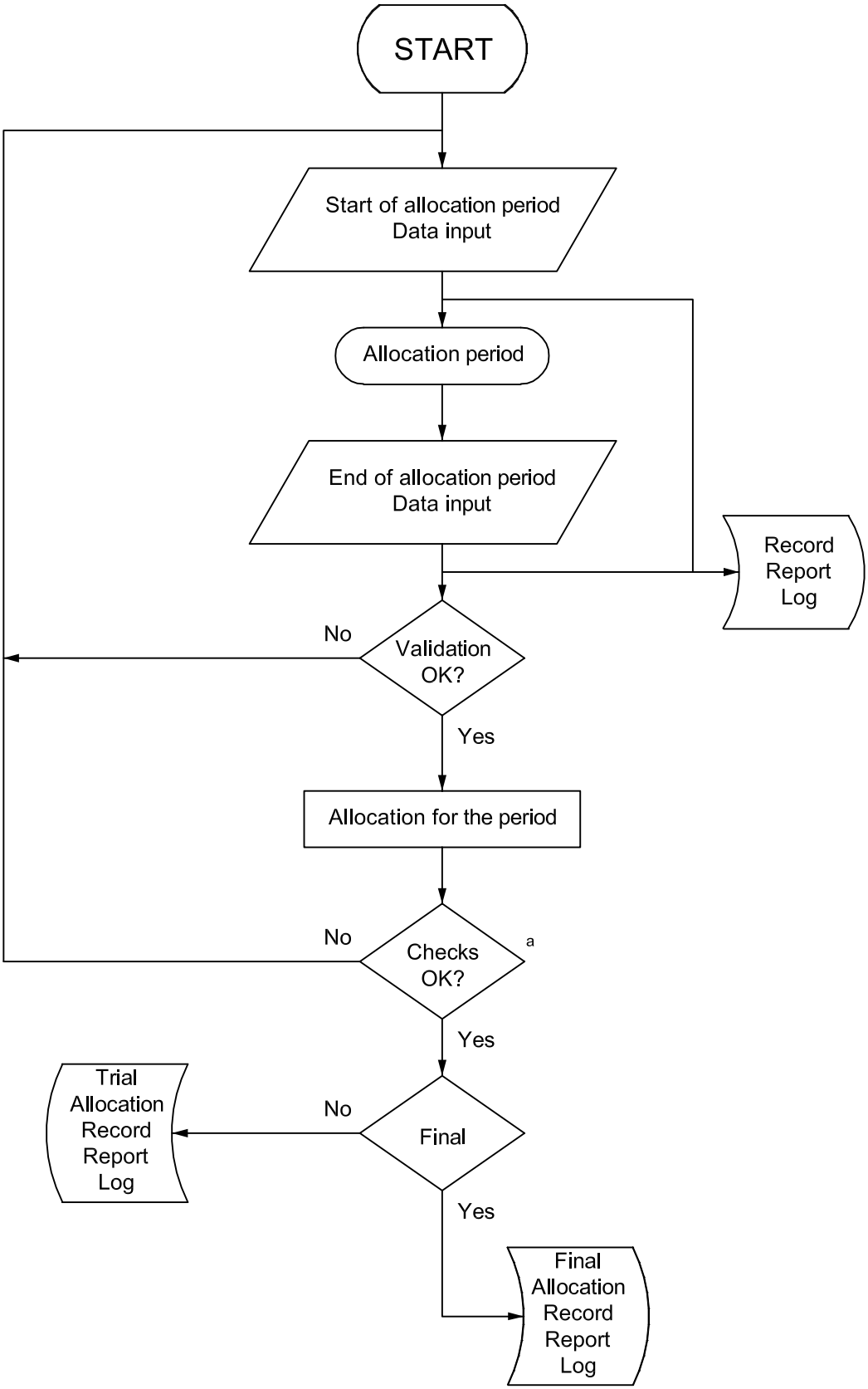


[a] Checks here also include the sub-process of reconciliation, or system balance, i.e. what is reported as being delivered with what has actually been received. This is usually done periodically and at agreed-upon intervals.

**Figure 7 — Typical allocation process flow chart**

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## 4.3 Physical system terms

### 4.3.1 Fluid definitions — General

Some definitions are given below for single-phase fluid streams (e.g. gas, water and liquid streams) and multiphase fluid streams (e.g. wet gas streams and multiphase streams). Unlike the downstream and transport and distribution businesses, for the upstream area it is not the case that all fluid streams are properly conditioned to a single phase or indeed stay in a single phase over a large range of pressure and temperature. In the upstream area, the fluids are often unstable, and any pressure and temperature change (even a $\Delta p$ in a measurement device or over a valve) can cause a phase change and change a single-phase fluid into a multiphase fluid. Accordingly, all definitions below should be referred to the operation ranges of temperature and pressure that occur in the system under consideration.

### 4.3.2 Definitions for fluids

**4.3.2.1**
**equation of state**
**EoS**
mathematical expression that relates the composition, pressure and temperature of a fluid

NOTE For an ideal gas, the equation of state is the ideal gas law. More complicated equations of state have been developed to model the behaviour of actual gases over a range of pressures and temperatures, e.g. Benedict, Webb, Rubin (BWR equation) and Soave, who modified Redlich & Kwong's equation (SRK equation).

**4.3.2.2**
**dry gas**
**treated gas**
clean dry gas (not necessarily only hydrocarbons but may contain other components such as $CO_2$, $N_2$, etc.) where no liquid is present and no liquid condensation is expected over the expected normal operating temperatures and pressures at the metering point

EXAMPLE Gas with a dew point of – 5 °C that is measured under conditions between 5 °C and 10 °C.

**4.3.2.3**
**equilibrium gas**
⟨separated at dew point⟩ dry gas at its dew point but without the presence of liquid condensation (typically gas at the outlet of a properly functioning separator)

NOTE Any change in temperature or pressure can cause a change of state of the gas towards a dry gas or a wet gas.

**4.3.2.4**
**wet gas**
⟨two- or three-phase⟩ any mixture of gas and up to about 10 % by volume liquid hydrocarbon and/or water

NOTE The mass ratio of gas to liquid varies significantly with pressure for a constant gas volume fraction. A convenient parameter to indicate the wetness of the gas is the Lockhart-Martinelli parameter (see 4.3.2.15).

**4.3.2.5**
**single-phase hydrocarbon liquid**
liquid at a pressure above its equilibrium pressure (bubble point)

EXAMPLE Liquid below the level of the outlet of a separator where static head (or booster pumps) increase(s) the pressure above the equilibrium pressure.

NOTE The hydrocarbon liquid can contain traces of water.


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**4.3.2.6**
**single-phase water**
water with a pressure above its equilibrium pressure (bubble point)

NOTE Some traces of liquid hydrocarbons may be present.

**4.3.2.7**
**equilibrium liquid**
**separated liquid at bubble point**
hydrocarbon liquid at its equilibrium pressure and temperature, which does not contain any gas

NOTE However, any further pressure or temperature change can cause gas to be released. True equilibrium liquid is very rare in gas-condensate processing as the dynamic nature of the processes does not allow sufficient time for liquids to reach equilibrium conditions.

**4.3.2.8**
**gassy liquid**
⟨two or three phases⟩ any mixture of hydrocarbon liquid and water at a pressure below its equilibrium pressure (bubble point) and where gas is present in the liquid mixture

NOTE This typically occurs inside a separator or where the liquid is exposed to a pressure reduction, e.g. cavitation.

**4.3.2.9**
**gas-oil ratio**
**GOR**
ratio of produced gas flow rate to the produced oil (condensate) flow rate

NOTE GOR is generally measured in standard units, e.g. cubic metres per cubic metre (standard cubic feet per barrel).

**4.3.2.10**
**gas-condensate ratio**
**GCR**
ratio of produced gas flow rate to the produced condensate flow rate

NOTE The GCR is generally measured in standard units, e.g. cubic metres per cubic metre (standard cubic feet per barrel).

**4.3.2.11**
**gas-liquid ratio**
**GLR**
ratio of produced gas flow rate to the produced total liquid flow rate

NOTE The GLR is generally measured in standard units, e.g. cubic metres per cubic metre (standard cubic feet per barrel).

**4.3.2.12**
**watercut**
**water-liquid ratio**
**WLR**
volumetric fraction of water in the total liquid stream (water plus liquid hydrocarbons), with both volumes determined at the same pressure and temperature

**4.3.2.13**
**water fraction**
volumetric fraction of water in the total fluid stream (water, liquid hydrocarbons and gas hydrocarbons), with both volumes determined at the same pressure and temperature

NOTE Water fraction is often used in wet-gas applications.

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**4.3.2.14**
**gas volume fraction**
**GVF**
ratio of produced gas flow rate to the produced fluid (gas plus liquid) flow rate

NOTE The GVF is generally measured under actual conditions, e.g. cubic metres per cubic metre, and expressed as a fraction.

**4.3.2.15**
**Lockhart-Martinelli parameter**
$X$

dimensionless parameter, useful in the analysis of multiphase flow, that is expressed as given in Equation (1):

$$X = \frac{Q_l}{Q_g} \cdot \sqrt{\frac{\rho_l}{\rho_g}} \qquad (1)$$

where

$Q_l$ is the liquid volume flow rate at line conditions, expressed in cubic metres per day;

$Q_g$ is the gas volume flow rate at line conditions, expressed in cubic metres per day;

$\rho_l$ is the liquid density at line conditions, expressed in kilograms per cubic metre;

$\rho_g$ is the gas density at line conditions, expressed in kilograms per cubic metre.

**4.3.2.16**
**multiphase fluid**
⟨oil and gas production⟩ mixture of the three phases: liquid hydrocarbon, water and gas

NOTE Almost all fluids encountered in oil and gas production are multiphase fluids. There are broad categories of multiphase fluid, e.g. wet gas (4.3.2.4) where the GVF is typically > 90 %; fluids from a wide range of oil wells where 5 % < GVF < 90 %; and the low-GVF, “gassy’ oils”. It is important to realize that “multiphase fluid” is not a well defined substance.

## 4.4 Definitions for allocation systems

NOTE See Annex D for lists of letters for 3-letter abbreviations.

### 4.4.1 Allocation principles

**4.4.1.1**
**mass component**
total mass of a single chemical component within a stream, the total of all components being equal to the total mass delivered by that stream

**4.4.1.2**
**energy**
⟨gas/condensate allocation⟩ heat energy released when the gas or condensate is subject to combustion under specified conditions

NOTE Energy may be expressed per unit mass, per unit (standard or normal) volume or per mole, at various reference temperatures and pressures, with or without the condensation energy of the water vapour formed during combustion. Reference can be made to ISO 6976 for further information.


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**4.4.1.3**
**yield factor**
expected returns of hydrocarbon liquids as a proportion of the potential liquids contained within a gas stream

**4.4.1.4**
**delivery point**
final measurement point(s) where hydrocarbons leave a single allocation stage

**4.4.1.5**
**source point**
entry of a product stream into a single allocation stage

NOTE Quantities associated with source points may be measured or derived.

**4.4.1.6**
**allocation point**
any node in an allocation system to which product is allocated

**4.4.1.7**
**components**
individual chemical compounds within a product stream

EXAMPLES $CH_4$, methane, also designated $C_1$; $C_2H_6$ , ethane, also designated $C_2$.

**4.4.1.8**
**lift gas**
gas that is pumped down a well to assist in that well's production

NOTE For the purposes of allocation, all the gas pumped down the well is assumed to be recovered with the well production fluids. However, the lift gas can mix with the reservoir gas and can change its composition. This can affect a volume-based allocation.

**4.4.1.9**
**injection gas**
gas injected into the field's reservoir to maintain reservoir pressure

NOTE The gas is not specific to any one producing well, as is the case with lift gas, and the gas might not appear from production wells until, perhaps, years after injection has begun. The allocation of injection gas is usually different from the allocation of lift gas.

**4.4.1.10**
**utility gas**
gas that is vented, flared or burnt as part of normal operations

NOTE Utility gas includes the following:

— vent/flare gas: It is necessary for all producing fields to have a means of maintaining a positive pressure in all vent lines from the processing facilities to atmosphere under normal operating conditions and also to have the capability to vent large amounts of gas in case of an emergency. At present, the method to do this is to continuously vent gas to atmosphere. Relatively small quantities of gas can be vented into the atmosphere un-ignited from some facilities. Usually, to make the gas safe, it is ignited on leaving the vent stack, when it is known as flare gas. This gas is waste product but it is necessary to account for it a) in normal operation, when there are usually small quantities and b) when large amounts are vented during an emergency. The allocation for these two scenarios is usually different.

— fuel gas: Fuel gas used by the plant is usually provided from the gas extracted from the incoming fluids. The allocation of fuel gas is usually driven by commercial or contractual considerations, so measurement applications can be very varied. New European environmental laws require operators to calculate the amount of $CO_2$ vented to the atmosphere; hence this requires the amount of $CO_2$ to be measured and allocated. (A component-based allocation system seems to be suitable for this.)

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— start-up gas: Gas imported from other facilities to fill pipelines or equipment on facilities prior to start-up. Depending on size and pressure of the system, these quantities of gas can be large [e.g. for a 300 km, 91.5 cm (36 in) pipeline operating at 13 MPa (130 bar)] and should be taken into account in the allocation process.

**4.4.1.11**
**condensate-gas ratio**
**CGR**
ratio of condensate to gas

NOTE The condensate-gas ratio can be expressed on either a mass or a volume basis.

**4.4.2**
**attribution**
process of calculating a final quantity for each allocation point based on its assigned substitution and allocated quantities

**4.4.3**
**substitution**
process, in any system where nominations are used to target deliveries of products, whereby the difference between target production (nomination) and allocated deliveries are reduced through exchanges between allocation points

**4.4.4**
**apportionment received at the allocation point**
process of pro-rating an allocated/attributed quantity where the same ownership exists for all sources

**4.4.5**
**system balance**
performance indicator used to track the difference between the sum of all sources and all delivery points for an allocation system or single allocation stage

**4.4.6**
**node**
any originating point to an allocation system or a point with two or more streams attached

**4.4.7**
**stream**
⟨allocation modelling⟩ line depicting the flow of product from a source node to a delivery node

**4.4.8**
**validation**
process of performing data checks

**4.4.9**
**mis-measurement**
process resulting in an erroneous quantity or quality value being recorded and entered into an allocation system

NOTE The error in the value can be caused by faulty or incorrect equipment, incorrect configuration or correction factors.

## 4.5 Allocation from a commercial viewpoint

### 4.5.1 General

Prior to entering into gas allocation system negotiations, it is important to understand the underlying framework of commercial agreements (either existing or being negotiated) and the technical characteristics of the production system, pipeline and terminal. For example, each system user's perception of the local gas


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market influences the importance that party places on different aspects of the allocation agreement, such as the following:

a) security of gas supply with the aim to sell gas on a long-term contract:

— allocation and attribution period set at a day,

— limited re-nomination with relatively long lead times,

— priority system for the attribution process,

— mechanisms for notified and system substitution,

— pipeline stock controlled by the pipeline system operator;

b) flexibility of gas supply in a de-regulated system with the aim to sell gas on the spot market:

— allocation period set at less than a day,

— relatively short re-nomination lead times,

— no priority system with the allocation process,

— no gas substitution,

— all nominations and re-nominations treated as firm,

— linepack controlled by the system users,

— within a day production changes to supplement gas delivery.

The specific situations are never as clear-cut as outlined above and there are other issues that impact the gas buyers and/or the system users, e.g. independence and capacity rights. However, unless a high-level analysis is undertaken and the main issues evaluated prior to entering into negotiations, then there is the likelihood that the allocation system will not fulfil the system users' requirements and objectives. In the extreme situation, the poor quality of the allocation system can impinge on the operation of the offshore production facility and/or can limit the opportunity to sell gas in the open market.

Allocation agreements are commercial agreements with technical input and not the other way around. Attempting to develop a gas-allocation system in isolation has the potential to produce an allocation system that does not fit either commercial or technical purposes. It is necessary to give consideration to the following issues.

— Is the gas being sold to single or multiple buyers?

— Is there one or are there multiple gas sales points?

— Is the gas being sold on a short-term or long-term contract basis?

— Is there a spot market available for gas sales?

— Are there penalties for under-delivery or off-spec delivery?

— Are there any restrictions in use of system capacity by a system user?

— How is the gas from the production system being used within a system user's gas sales portfolio?

— What is the flexibility in the production system to respond to required changes in flow rate?

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— Are there any local statutory regulations/considerations with respect to measurement devices, reporting and/or gas balancing?

### 4.5.2 Gas-allocation issues

To develop a gas-allocation system requires an understanding from a technical standpoint of all aspects of the overall process design and operation, including the implications on the terminal product of variations in processing conditions and gas compositions, and from a commercial standpoint of the gas sales agreements and the overall commercial structure that has been developed.

By its very nature, a gas-allocation system encompasses a wide range of topics including measurement methods and standards, laboratory techniques, data auditing, allocation principles and procedures, nomination, substitution and attribution procedures, statutory requirements, IT system development, audits, tax and related commercial transportation, operating and processing system agreements. The various issues are further explained in the remainder of this Technical Report.

### 4.5.3 Technical issues

#### 4.5.3.1 Measurement

Measurement includes metering and sampling and is required to establish the quantity and associated quality of the gas exported from the production system into the pipeline and the product leaving the terminal. An understanding is required of the different types of metering systems, sampling installations and associated analytical techniques. This information is required to ensure that the meter specified is correct for the service and accuracy and that the sampling installation is installed in the appropriate location.

The specification of metering and sampling equipment at each measurement point should be designed in accordance with applicable standards and local regulations, although it should be noted that commercial considerations can have an impact on this specification. For example, it may be agreed that a marginal field may use a standard of metering with a higher uncertainty if the overall financial risk is mitigated. Measurement points include

— pipeline entry measurement point(s) for gas and liquid,

— terminal entry measurement point,

— terminal measurement exit point(s) for gas and liquid,

— terminal fuel gas,

— terminal flare gas,

— liquid storage.

In addition, the sampling systems are utilized to monitor the entry and exit streams to ensure that the composition specifications are achieved.

#### 4.5.3.2 Terminal product slate

The terminal product slate relates to the onshore processing of the commingled gas stream in order to ensure that the sales gas and associated liquid product(s) meet the required specifications. In general, more liquid products requires a more complex allocation procedure. An understanding of the terminal process design is required to ensure that the developed procedures correctly reflect each field's allocated entitlement.


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#### 4.5.3.3 Pipeline capacity

Pipeline capacity relates to the steady-state and transient operation of the gas pipeline. It is important to ensure that the allocation mechanisms do not inhibit pipeline operation and *vice versa*.

#### 4.5.3.4 System response time

System response time relates to the speed at which the offshore process, the pipeline and the onshore terminal can individually respond to a required change in system throughput. An understanding is required because of the necessity to ensure that the process reflects the dynamics of the system.

#### 4.5.3.5 Gas sales agreement

The gas sales agreement specifies the gas specification at the re-delivery point, nomination procedures, forecasting and gas measurement required and, therefore, directly impacts the allocation process. An understanding is required to ensure that the allocation agreement enables the principles of the gas sales agreement to be applied or that the gas sales agreement can be negotiated to fit with the system's allocation agreement.

#### 4.5.3.6 Commercial agreements

The commercial agreements relate to the transportation and processing agreements that specify, among other things, capacity rights, specifications and system-wide capacity constraint procedures.

#### 4.5.3.7 Statutory obligations

The statutory obligations relate to specific reporting requirements, which can be technical (e.g. measurement), that are necessary to incorporate into the agreements.

#### 4.5.3.8 Tax implications

Processes should be developed for the tax implications that recognize those fields that are liable for specific taxes and those that are not liable. Consideration should be given to the most tax-efficient option when developing the allocation procedures.

### 4.5.4 Commercial issues

#### 4.5.4.1 Allocation

Allocation is the procedure for sharing out the terminal's gas and liquid production between the participating fields based on the measured data. Allocation relates to the physical movement of fluids through the system.

A series of mathematical equations has been developed to trace the physical flow of gas exported from a field through the pipeline to the terminal. The procedures are used to determine each field's and the associated system user's share of the terminal production (gas and liquids) based on the physical quantity of gas entering the pipeline.

#### 4.5.4.2 Attribution

Attribution is the procedure for sharing out the terminal's gas production between the participating fields, primarily based on nomination data. Attribution relates to the commercial movement of gas through the system and can be independent of the measured input quantities.

A series of mathematical equations has been developed to establish each system user’s share of the gas exported from the terminal. The procedures are based on the user's gas allocation, nomination and specific substitution rights.

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