



BSI Standards Publication

Design and operation of allocation systems used in gas productions facilities

National foreword

This Published Document is the UK implementation of ISO/TS 26762:2025. It supersedes PD ISO/TR 26762:2008, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee CPI/30/2, Differential pressure methods.

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© The British Standards Institution 2025
Published by BSI Standards Limited 2025

ISBN 978 0 539 29462 0

ICS 75.060; 75.160.30

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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 April 2025.

Amendments/corrigenda issued since publication

Date	Text affected
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Technical Specification

ISO/TS 26762

Design and operation of allocation systems used in gas productions facilities

*Conception et opération des systèmes d'allocation dans les
installations de production de gaz*

**First edition
2025-04**

Reference number
ISO/TS 26762:2025(en)

Full document details: PD ISO/TS 26762:2025

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Published in Switzerland

Contents

	Page
Foreword	vii
Introduction	viii
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
3.1 Fluids	2
3.2 Definitions for allocation systems	4
3.3 Streams	6
4 Allocation fundamentals	7
4.1 Allocation definition and objective	7
4.2 Allocation and metering	7
4.3 Gas productions facilities	7
4.4 Allocation applications and cases	8
4.5 Allocation types and classification	8
4.5.1 General	8
4.5.2 Technical allocation	8
4.5.3 Contractual and fiscal allocation	9
4.6 Allocation in the value realization chain	9
4.7 Allocation boundaries and steps	11
4.8 Physical streams	12
4.8.1 General	12
4.8.2 Products	12
4.8.3 Input streams	13
4.8.4 Fluid characteristics	13
4.8.5 Gas and liquid compositions	13
4.9 Allocation process	13
4.10 Gas allocation cases summary	14
4.11 Allocation methodology	14
4.12 Balance and reconciliation	15
4.12.1 Balance	15
4.12.2 Reconciliation	17
4.13 Units	17
4.14 Upstream allocation example	17
4.15 Contractual gas allocation	18
4.15.1 General	18
4.15.2 Gas-allocation issues	19
4.15.3 Measurement	19
4.15.4 Terminal products	20
4.15.5 Pipeline capacity	20
4.15.6 System response time	20
4.15.7 Agreements	20
4.15.8 Regulatory	21
4.15.9 Commercial issues	21
4.15.10 Time period	21
4.15.11 Forecasting	21
4.15.12 Pipeline stock	22
4.15.13 Existing systems	22
4.15.14 Data timing	22
4.15.15 Data flow and reporting	22
4.15.16 Auditing	22
4.15.17 Fallback	22
4.15.18 Summary	22
5 Fluid property and parameters for allocation	23

5.1	Fluid types.....	23
5.2	Gas and liquid properties.....	24
5.2.1	General.....	24
5.2.2	Stabilized fluids.....	24
5.2.3	Equilibrium gas (separated gas at dew point).....	24
5.2.4	Equilibrium liquid (separated liquid at bubble point).....	24
5.2.5	Flash calculations for non-stabilized and wet gas flows.....	24
5.3	Fluid information for allocation.....	25
5.3.1	Fluid compositions.....	25
5.3.2	Fluid properties.....	25
5.3.3	Allocation process factors for gas allocation.....	26
5.3.4	Blending effect.....	29
5.4	Use of phase behaviour/process simulation models.....	29
5.4.1	Introduction.....	29
5.4.2	Applications.....	30
5.4.3	Process simulation model types.....	30
5.4.4	Fundamentals of a process simulation model.....	31
5.4.5	Using process simulation models.....	31
5.4.6	Construction of a process simulation model.....	32
5.4.7	Modelling approaches.....	33
5.4.8	Example of process simulation modelling for allocation: calculation of shrinkage factors.....	34
6	Measurements, sampling and analysis.....	36
6.1	General.....	36
6.2	Flow measurements.....	36
6.2.1	Single-phase liquid measurement.....	36
6.2.2	Multiphase measurements.....	37
6.2.3	Gas measurement.....	37
6.2.4	Wet gas and multiphase fluids.....	39
6.2.5	Indirect methods.....	40
6.2.6	Virtual metering.....	40
6.2.7	Measurement uncertainty.....	40
6.3	Sampling.....	41
6.3.1	General.....	41
6.3.2	Single phase gas.....	41
6.3.3	Single-phase liquid.....	41
6.3.4	Wet gas sampling.....	41
6.3.5	Multiphase sampling.....	42
6.3.6	PVT sampling.....	42
6.3.7	Considerations on sampling points.....	42
6.3.8	Sampling of gas containing sulfur compounds.....	42
6.4	Analysis.....	43
6.4.1	Wet gas composition analysis.....	43
6.4.2	Gas chromatographic method for compositional analysis.....	43
6.4.3	Laser Raman spectroscopy and infrared spectroscopy method.....	43
6.4.4	Analysis for geochemical fingerprinting.....	43
6.4.5	Sulfur content analysis.....	43
6.4.6	Water content analysis.....	43
6.4.7	Analysis of gaseous water.....	43
6.4.8	Analysis of liquid water fraction.....	43
6.4.9	Water-liquid ratio for liquid.....	44
6.4.10	Determination of particles content.....	44
6.4.11	Wet gas physical parameters measurement.....	44
6.4.12	Density.....	44
6.4.13	Compression factor.....	44
6.4.14	Speed of sound.....	45
6.4.15	Calorific value.....	45
7	Allocation principles.....	45

7.1	General.....	45
7.2	Allocation methods.....	45
7.3	Allocation units for gas allocation	46
7.4	Proportional allocation.....	46
7.4.1	General	46
7.4.2	Pro rata based on estimations.....	48
7.4.3	Component mass pro rata.....	49
7.5	Allocation by by-difference	50
7.6	Allocation by process simulation.....	50
7.7	Uncertainty based allocation.....	51
7.8	Geochemical fingerprinting.....	53
7.9	Conversion calculation	53
7.9.1	Mass allocation conversion into volume.....	53
7.9.2	Mass allocation conversion to energy.....	55
7.10	Quantity allocation	56
7.10.1	General.....	56
7.10.2	Mass-quantity allocation.....	57
7.10.3	Volume quantity allocation.....	57
7.10.4	Energy-quantity allocation.....	57
7.11	Allocation calculations.....	57
7.11.1	General.....	57
7.11.2	Calculations at the measurement points	57
7.11.3	Allocated field's share.....	60
7.12	Allocation methodology selection.....	63
7.13	Balancing and reconciliation calculations.....	64
7.13.1	General.....	64
7.13.2	Reconciliation	64
7.13.3	Balancing and reconciliation accounts.....	65
8	Utility and disposed gas allocation	65
8.1	General.....	65
8.2	Utility gas allocation by volume.....	67
8.3	Injection and sales (purchase) gas allocation.....	69
8.4	Export gas and oil mass and volume.....	70
9	Inventory	70
10	Allocation cases and typical lay out	71
10.1	Allocation cases.....	71
10.1.1	General.....	71
10.1.2	Well allocation and well production.....	72
10.1.3	Asset, field and subgroup, upstream allocation	73
10.1.4	Pipeline, midstream allocation.....	73
10.1.5	Terminal, downstream allocation.....	73
10.1.6	Liquid natural gas	74
10.1.7	Carbon dioxide CO ₂	74
10.1.8	New development tied into an existing one	74
10.1.9	New development tied into an existing transportation system.....	75
10.2	Typical allocation lay out.....	75
10.2.1	Gas only.....	75
10.2.2	Dry gas in, dry gas and liquid out.....	76
10.2.3	Wet gas combined in, dry gas and liquid out.....	76
10.2.4	Dry gas and liquid in; dry gas and liquid out	77
11	Allocation uncertainty (from HM 96)	78
11.1	General.....	78
11.2	Relative and absolute uncertainty.....	78
11.3	Uncertainty of a calculated value -analytical solution	78
11.4	Allocation per difference.....	79
11.5	Proportional/pro rata allocation.....	80
11.6	Uncertainty based allocation.....	81

11.7	Uncertainty of a calculated value – other methods	82
11.8	Uncertainty contributors	82
12	Allocation systems design and integration	82
12.1	General	82
12.2	Metering and allocation philosophy	85
12.3	Allocation agreements	85
12.4	Regulations	85
12.5	Development procedure	85
12.5.1	General	85
12.5.2	Step 1	86
12.5.3	Step 2	87
12.5.4	Step 3	87
12.5.5	Step 4	88
13	Operation of allocation systems	88
13.1	General	88
13.2	Input QA/QC	90
13.3	Imbalance follow up	90
13.4	Trending	91
13.5	Surveillance	91
13.6	Validation	91
13.6.1	General	91
13.6.2	Meter validation	92
13.6.3	Allocation procedures and process validation	92
13.6.4	Data validation	93
13.6.5	Data reconciliation	93
13.6.6	Process-model validation	93
13.6.7	Allocation-process results validation	93
13.6.8	Software validation	94
13.7	Mismeasurement handling	94
14	Audits	95
14.1	General	95
14.2	Metering and allocation audit objectives	95
14.3	MandA audit boundary and activity	95
14.3.1	Installations	95
14.3.2	Systems	95
14.3.3	Metering and allocation activity	96
14.4	Audit scope	96
14.5	Audit findings	97
14.5.1	General	97
14.5.2	Audit exceptions	97
14.5.3	Audit recommendations	97
14.5.4	Audit observation	97
14.5.5	Allocation audit checklist	97
	Annex A (informative) Exposure to loss/risk assessment	99
	Bibliography	103

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 193, *Natural gas*, Subcommittee SC 3, *Upstream area*.

This first edition cancels and replaces ISO/TR 26762:2008, which has been technically revised.

The main changes compared to the previous edition are as follows:

- revision and update of flow and analysis measurement part;
- detailed description of all allocation methods;
- development of fluid property calculation and process simulation part;
- development of a specific uncertainty clause with examples;
- integration of well allocation part in addition to purely commercial allocation;
- extension of design considerations as well as operation considerations;
- incorporation of a specific clause on allocation audits.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Allocation is the procedure for sharing production and products belonging to different users of shared facilities when such production and products result from processing and transport of streams in a commingled way ([Figure 1](#)).

For instance, allocation is performed to attribute oil, gas and water production back to production wells when these wells are produced and processed in the same facilities. Correct well allocation has a high impact on reservoir management and cost related to well overhauls.

More critically, allocation of hydrocarbons and associated streams is performed when different licenses with different equity share are tied into a shared process facility, pipeline or plant. Allocation calculations are used to determine each license's and/or owner's allocated share of the outgoing new comingled stream(s) directed to the delivery/sales point. The allocated share in volume, mass or energy is required for gross company revenue, tariffs, duties, fees and taxes.

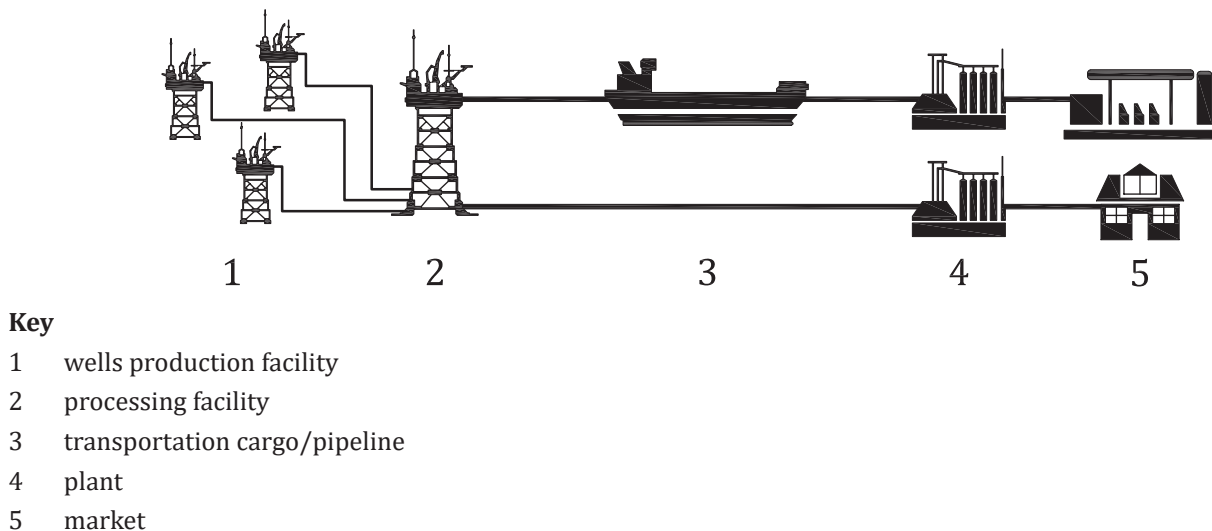


Figure 1 — Schematic view of a typical allocation system

The intention is to conduct allocation in acceptable terms to ensure the license/owners receive their fair share of the comingled stream and that no parties experience unnecessary or unknown losses.

The allocation of gas and other products is a result of field development, technical design, investments and commercial negotiation and agreements. There are multiple combinations of allocation methods and calculations. Most of the allocation systems and hydrocarbon value realization chains are unique. As more fields and licenses are connected to common process facilities or transportation infrastructure, the complexity increases to ensure owners get a fair return on investment and production. Small bias to measurements over time can result in errors that represent large amounts of money. However, it can be too costly to invest in a low measurement uncertainty of a minor production stream. Cost-benefits and uncertainty analyses of the value chain are a good way to understand the cost of maximizing return on investment.

To design, evaluate, audit or operate an allocation system/method for gas and associated liquids, it is necessary to have competence within fluid thermodynamic properties, flow characteristics, gas treatment/processing, measurement, process simulation, sampling, allocation principles, uncertainty calculations and the value realization chain for the given application.

As sustainable computer systems are necessary to handle the allocation calculation on a regular basis and storing data securely, IT skills are also required.

ISO/TS 26762:2025(en)

This document comprises the most common or recommended allocation principles, systems, uncertainty, and calculation of possible losses, including some evaluation of risk for losses. Some clauses are directly derived from HM 96 developed by Energy Institute which very generously allowed ISO to use them.

Design and operation of allocation systems used in gas productions facilities

1 Scope

This document specifies how to design and operate allocation systems for gas production facilities.

It describes the most common types, principles and methods used for the allocation of gas and associated liquids. The objective is to provide an approach to current best practice in the oil and gas industry.

It applies to gas and liquid allocations to be performed in production, processing, transportation, storage and terminal installations dealing with natural gas and associated liquids as well as end products like sales gas, liquefied petroleum gas (LPG), liquefied natural gas (LNG), condensate and to some extent non-hydrocarbon gases like CO₂, H₂.

This document provides the minimum information needed to develop and implement allocation procedures and systems both for internal purposes (well allocation) and fiscal or commercial applications with different owners and stakeholders.

This document can be used to develop gas and liquid processing and transportation agreements and regulatory documents as well as to conduct audit of measurement and allocation systems.

It also introduces the areas of competence needed and the terminology used in the industry.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5167 (all parts), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full*

ISO 10715, *Natural gas — Gas sampling*

ISO 14532, *Natural gas — Vocabulary*

HM 96, *Guidelines for the allocation of fluid streams in oil and gas production*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14532, HM 96 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 Fluids

3.1.1

condensate-gas ratio

CGR

ratio of condensate to gas

Note 1 to entry: The condensate-gas ratio can be expressed on either a mass or a volume basis.

3.1.2

dry gas

gas in vapor phase containing no liquids.

Note 1 to entry: Gas is not necessarily only hydrocarbon but can contain other components such as CO₂, N₂, etc. There is no liquid entrainment 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.

3.1.3

equation of state

EOS

mathematical expression that relates the composition, pressure and temperature of a fluid

Note 1 to entry: 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 and Kwong's Formula (SRK equation).

3.1.4

equilibrium gas

(dry gas) at its dew point but without the presence of liquid condensation

Note 1 to entry: Any change in temperature or pressure can cause a change in state of the gas towards a dry gas or a wet gas.

Note 2 to entry: Separated at dew point.

Note 3 to entry: Typically gas at the outlet of a properly functioning separator.

3.1.5

equilibrium liquid

separated liquid at bubble point

hydrocarbon liquid at its equilibrium pressure and temperature, which does not contain any gas

Note 1 to entry: 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.

3.1.6

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

3.1.7

gas-oil ratio

GOR

ratio of produced gas flow rate to the produced oil (condensate) flow rate

Note 1 to entry: GOR is generally measured in standard units, e.g. cubic meters per cubic meter (standard cubic feet per barrel).

3.1.8

gas-condensate ratio

GCR

ratio of produced gas flow rate to the produced condensate flow rate

Note 1 to entry: The GCR is generally measured in standard units, e.g. cubic meters per cubic meter (standard cubic feet per barrel).

3.1.9

gas-liquid ratio

GLR

ratio of produced gas flow rate to the produced total liquid flow rate

Note 1 to entry: The GLR is generally measured in standard units, e.g. cubic meters per cubic meter (standard cubic feet per barrel).

3.1.10

gas volume fraction

GVF

ratio of produced gas flow rate to the produced fluid (gas plus liquid) flow rate

Note 1 to entry: The GVF is generally measured under actual conditions, e.g. cubic meters per cubic meter, and expressed as a fraction.

3.1.11

multiphase fluid

(oil and gas production) mixture of the three phases: liquid hydrocarbon, water and gas

Note 1 to entry: Almost all fluids encountered in oil and gas production are multiphase fluids. There are broad categories of multiphase fluid, e.g. wet gas where the GVF is typically $> 90 \%$; fluids from a wide range of oil wells where $5 \% < \text{GVF} < 90 \%$; and low-GVF, "gassy" oils. "Multiphase fluid" is not a well-defined substance.

3.1.12

single-phase 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 1 to entry: The liquid can contain traces of water.

3.1.13

water fraction

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

Note 1 to entry: Water fraction is often used in wet-gas applications.

Note 2 to entry: Water fraction can be expressed in mass fraction.

Note 3 to entry: Water fraction can be expressed in percentage.

3.1.14

wet gas

(two- or three-phase) any mixture of gas and up to about 10% by volume liquid hydrocarbon and/or water

Note 1 to entry: 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.

3.2 Definitions for allocation systems

3.2.1

allocation process

calculation by which a quantity of products measured at a node is allocated to one or more contributing sources, fields or owners

Note 1 to entry: Allocation units are either volume, mass or energy.

3.2.2

attribution

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

3.2.3

components

individual chemical compounds within a product stream

EXAMPLE 1 CH_4 , methane, also designated C_1 .

EXAMPLE 2 C_2H_6 ethane, also designated C_2 .

3.2.4

data reconciliation

adjustment of measurement data to conform to balance constraints that can apply

Note 1 to entry: Data reconciliation uses statistical methods to ensure the weighted sum of the squares of the differences between the measurements and their revised values are minimized.

Note 2 to entry: The technique considers the uncertainties and gives more weight to measurements that are expected to be most accurate.

3.2.5

delivery point

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

3.2.6

energy

heat energy released when the gas or condensate is subject to combustion under specified conditions

Note 1 to entry: Energy can 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 vapor formed during combustion. See ISO 6976 for further information.

3.2.7

entry point

entry of a stream into an installation

Note 1 to entry: Quantities associated with entry points can be measured or derived.

3.2.8

gas facilities

any installation receiving, processing, transporting or storing hydrocarbons for further natural gas production

3.2.9

products

any fluid marketable or not, derived from processing wet gas or gas like sales gas, liquefied petroleum gas and liquefied natural gas

Note 1 to entry: Gas products also include nonhydrocarbon liquid like CO_2 as well as associated liquids and condensed liquids like water and hydrocarbon condensates.

3.2.10

gas recovery factor

mass of gas obtained after processing divided by total hydrocarbon mass input

3.2.11

injection gas

gas injected into a field's reservoir to maintain reservoir pressure

Note 1 to entry: The gas is not specific to any one producing well, as is the case with lift gas. It is possible that the gas does not appear from production wells until years after injection has begun.

Note 2 to entry: The allocation of injection gas is usually different from the allocation of lift gas.

3.2.12

imbalance

physical difference between outputs and inputs corrected for any change in stock

3.2.13

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

3.2.14

node

any originating point to an allocation system or a point with two or more streams attached.

3.2.15

mismeasurement

process resulting in an erroneous quantity or quality value being recorded and entered into an allocation system

Note 1 to entry: The error in the value can be caused by faulty or incorrect equipment, incorrect configuration, or correction factors.

3.2.16

oil recovery factor

ORF

quantity of oil obtained after processing divided by total hydrocarbon input

Note 1 to entry: Usually defined by component.

3.2.17

shrinkage factor

volume or mass change of hydrocarbon liquids from upstream process to end-of-process conditions

Note 1 to entry: Change is generally reduction.

3.2.18

simulation model

process engineering model simulating processing facilities for the calculation of allocation parameters

Note 1 to entry: Like but not limited to recovery factors, volume conversion factors, fluid properties for allocation.

3.2.19

source

entry of a product stream into a single allocation stage

Note 1 to entry: Quantities associated with source points can be measured or derived.

3.2.20

stream

(allocation modelling) line depicting the flow of product from a source node to a delivery node

3.2.21**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

3.2.22**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

3.2.23**validation**

process of performing data and measurement checks

3.2.24**well allocation**

split of produced or injected quantities back to each production or injection well

3.2.25**yield factor**

expected returns of hydrocarbon liquids as a proportion of the potential liquids contained within a gas stream

3.3 Streams**3.3.1****injection gas**

gas injected into the field's reservoir to maintain reservoir pressure

Note 1 to entry: The gas is not specific to anyone 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.

3.3.2**lift gas**

riser gas

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

Note 1 to entry: 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.

3.3.3**utility gas**

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

Note 1 to entry: Utility gas includes the following:

- Vent/flare gas: All producing fields shall have a means of maintaining a positive pressure in all vent lines from the processing facilities to atmosphere under normal operating conditions and 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 the 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 CO₂ vented to the atmosphere; hence this requires the amount of CO₂ to be measured and allocated. (A component-based allocation system seems to be suitable for this.)

- Start-up gas: Gas imported from other facilities to fill pipelines or equipment on facilities prior to start-up. Depending on the 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 considered in the allocation process.

4 Allocation fundamentals

4.1 Allocation definition and objective

Allocation is the mathematical process used to determine the part of productions and products quantity belonging or to be attributed to each of contributors (fields/wells) and users of some installations when they are sharing such installations.

In such cases, productions/products to be attributed and allocated to each user cannot be measured directly. Consequently, allocation calculation using dedicated measurements and information shall be developed and implemented.

The objective is to conduct allocation according to acceptable and agreed methods to ensure the contributors and license owners obtain their fair share of the comingled stream from gas facilities and that no parties experience unnecessary or unknown losses.

4.2 Allocation and metering

Allocation implementation requires flow information i.e. flow or quantities as well as flow composition and fluid properties.

Allocation and metering including fluid analysis are complementary. They cannot be dissociated and shall be treated consistently for optimization purposes to define allocation and metering concept.

4.3 Gas productions facilities

Gas production facilities include all installations involved in production, transportation, processing and storage of gases, associated liquid and water as well as end products like dry gas, LPG, LNG, condensate. Allocation also applies to facilities dealing with nonhydrocarbon gas like H₂ or CO₂.

There can be a large variety of facilities or systems concerned with gas allocation; see [Table 1](#).

Table 1 — Typical gas facilities

Gas facilities	Products
Gas/condensate wells	Raw gas and liquids
Subsea networks	Gas and liquids/methanol
Upstream production facility including pipeline, gathering and processing facilities	Gas, water and condensate
Transportation system	Gas and liquids
Gas terminal	Sales gas and liquids
Gas storages including CO ₂	Gas, water and GCO ₂
LNG plant	LNG, gas, liquids
CCS facilities	LCO ₂ , GCO ₂
H ₂ facilities	LH ₂ , GH ₂

The nature of gas facilities installations (onshore, offshore, subsea) dictates equipment selection for measurement and analysis and consequently affects allocation system definition.

4.4 Allocation applications and cases

Allocation shall be performed whenever at least one of following scenarios is found:

- no individual measurement of production and products from wells, fields, etc.;
- commingled processing/transportation;
- different usage of commodities by fields /system users;
- different operators;
- different percentage ownership/tax regimes for wells and fields.

When allocation is required, allocation systems shall be designed and implemented combining measurements, sampling, analysis and calculation to accurately determine the quantity of end products to be allocated to each field or owner.

The allocation of gases depends on facilities as well as streams and stakeholders involved in process. Some potential cases are listed below:

- allocation of gas and liquid to production wells and installations: subsea or topside;
- allocation of pipeline outlets to shippers;
- allocation of commercial products to producers;
- allocation of utility gas (fuel gas, gas lift) to users;
- flare and gas release (vent) allocation to contributors.

4.5 Allocation types and classification

4.5.1 General

Allocation can be:

- technical, i.e. addressing physical quantities/volumes;
- contractual, i.e. to reflect agreements in place and calculate the ownership of each stakeholder or partner in a given contract.

4.5.2 Technical allocation

Technical allocation applies to procedures used to calculate individual contributions of each well to a global production/injection. The technical allocation is mainly done daily and monthly but can also be hourly for assets dealing with gas sales agreements.

An example of technical allocation is production well allocation. This consists of calculating well productions based on well estimations models and reference quantities measured from production facilities outlets (fiscal measurements) and intermediate reference measurements.

The main purposes of technical allocation are:

- to report consolidated/validated figures on each well to partners (daily and monthly);
- to provide the same consolidated figures internally to the departments for operations, well performance, and reservoir management as input data for wells and reservoir models simulations.

4.5.3 Contractual and fiscal allocation

Contractual allocation can be different from technical allocation. A contractual allocation is governed by allocation agreements and commercial agreements. It determines the final ownership of installation users as well as their contribution and usage in utilities and/or disposals which can influence net allocated quantities.

In other words, contractual allocation considers how to calculate net quantities and final products to be allocated to users of shared facilities. It does so by considering the allocation of disposals and utilities like fuel gas, which can be user-specific.

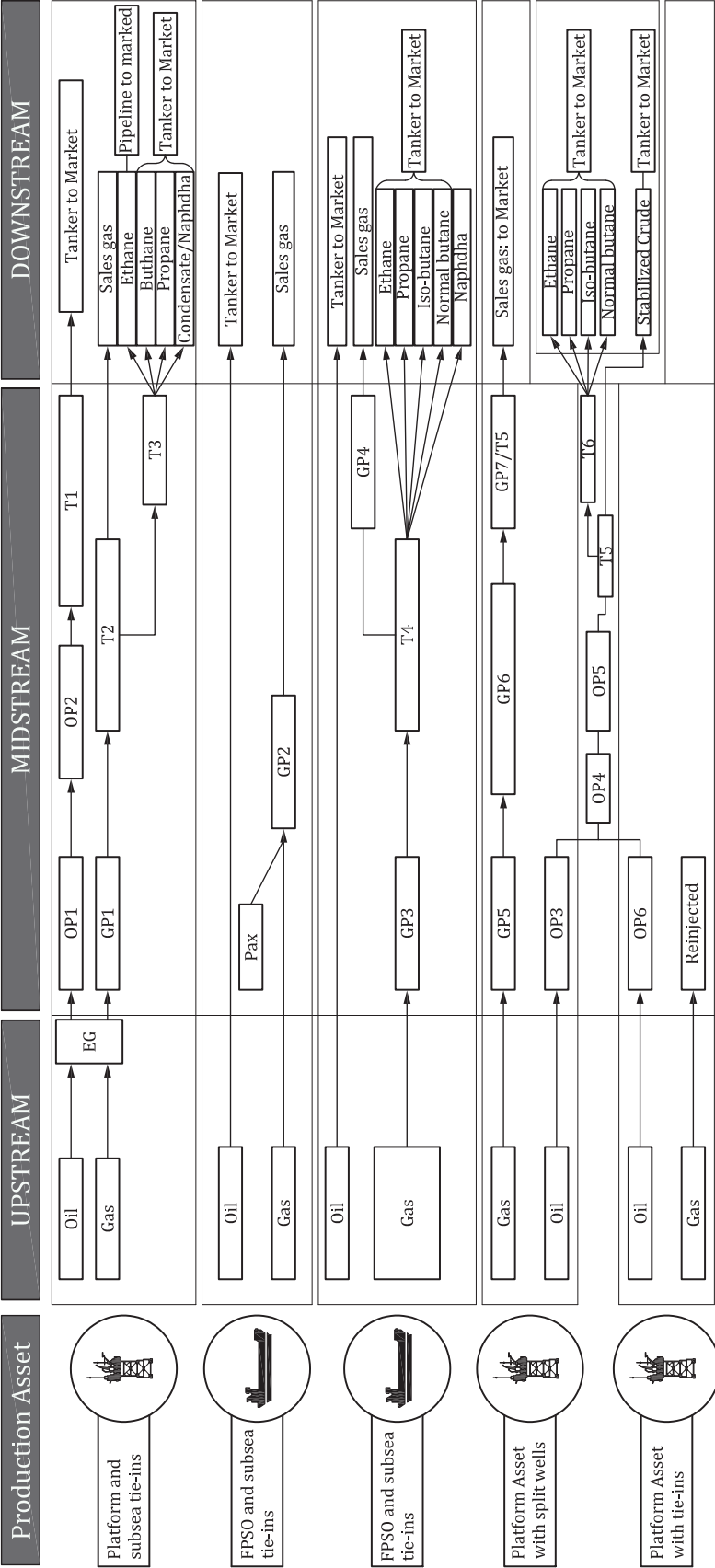
Allocation used to calculate ownership of different users of a system for revenue and taxation purposes can also be referred to as fiscal allocation.

For contractual and fiscal allocation, calculation principles and formulae as well as associated measurements for allocation shall conform to agreements in force between different entity.

4.6 Allocation in the value realization chain

Depending on the installation, allocation can be performed in several steps or areas.

For example, the hydrocarbon value chain can be divided into upstream, midstream and downstream areas with different operators. A hydrocarbon management or allocation system can be designed and used for upstream, midstream and/or downstream areas or for the whole hydrocarbon value realization chain. Each operator has their own allocation system; see [Figure 2](#).



- Key**
- EG export gas
 - Pa production asset
 - GPx gas pipeline x

SG sales gas
 OPx oil pipeline x
 Tx terminal/plant

Figure 2 — Hydrocarbon value chain

A hydrocarbon flow stream consists of several products. The value of the fluid is dependent on the composition of the products. If the hydrocarbon stream at the end of the value chain is sold by single products or energy, the components or the gross calorific value (GCV) shall be tracked through the value chain. The GCV and density can be calculated from the gas composition (see ISO 6976).

In a hydrocarbon value chain, there can be several commingle or split points related to processing or transportation with other producers. The properties/value of the fluid changes after each point. The change should be documented/calculated by adequate (quantity) measurements and (quality) sampling.

4.7 Allocation boundaries and steps

Allocation boundaries describe the physical set up, i.e. the installations or networks concerned, of a specific allocation with its specific input and output streams as per [Table 2](#).

When designing allocation systems, a key issue is to identify and define the allocation boundaries with their different sub-perimeters as well as the steps to take to ensure consistent reconciliation and allocation calculations.

Table 2 — Allocation boundaries

Perimeter	Products examples	Typical input streams
Terminal/delivery point	Sales gas Fuel gas Stabilized crude oil Condensate Water	Field exports
Pipeline	Oil, gas, water	Installations deliveries/field exports
Central production facilities	Oil, gas, water exports, water discharged	
Offshore platform/subsea line	Oil and gas outlets Water disposals	Wells streams and flow lines

In a classical system with large boundaries, including all installations between terminal and wells as per [Figure 3](#), allocation is performed using the five steps outlined in [Table 3](#).

Table 3 — Example of allocation steps

Step number	Description
1	Plant streams, i.e. export/sales gas + condensate + utility gas from plant P to be allocated to A, B and C
2	A production as well as utility gas from A to be allocated to A1, B2 and B3
3	B production as well as utility gas from B to be allocated to B1 and C1
4	C2 allocated production estimated from C minus utility gas from C
5	Well back allocation from A1, B1, B2, C1 and C2 back to wells

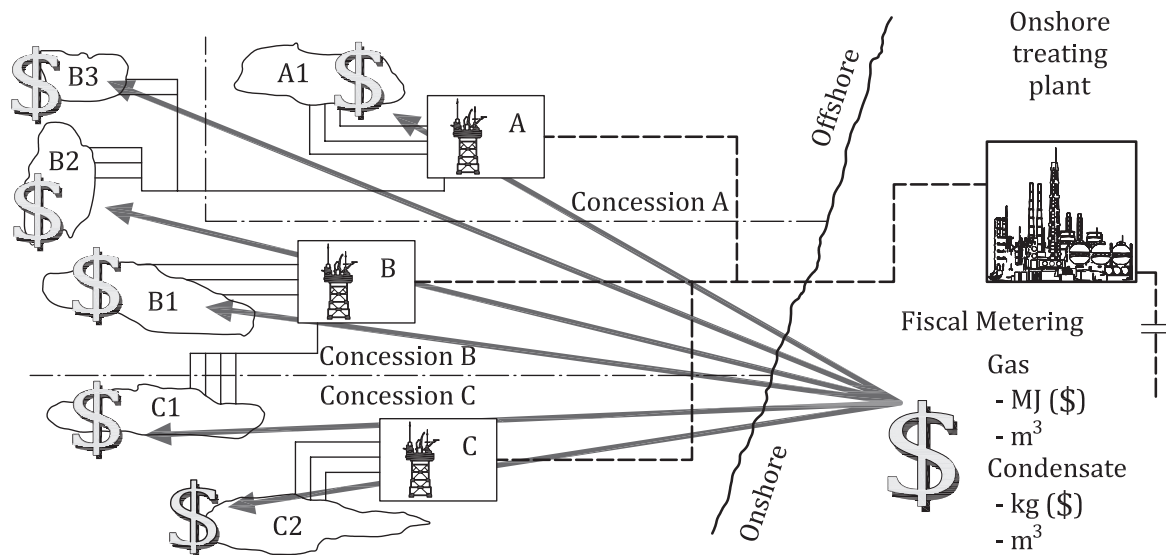


Figure 3 — Well to terminal system

4.8 Physical streams

4.8.1 General

Prior to allocation calculation, all streams taking part in allocation shall be identified and characterized in terms of property and fluid thermodynamical state.

Key streams include both output streams and products which shall be allocated and input streams corresponding to stream entering facilities via an entry point before being commingled and processed to give products.

4.8.2 Products

Products are the quantities which shall be allocated between contributors and users. From an allocation viewpoint, products are usually either at the point of sale or disposal, or feed into another allocation system.

However, these product streams are not restricted to streams providing sales value for users. With the increasing emphasis on monitoring and reporting of emissions and discharges (including taxes, tariffs, penalties and trading schemes) streams for disposal, such as produced water, fuel gas and flare, can have a direct financial impact and shall be included. These are normally treated as products streams.

See [Table 4](#). Products streams can include:

- any marketable products derived from processing wet gas or gas like sales gas, LPG and LNG;
- nonhydrocarbon gases like CO₂;
- associated liquids produced by gas and gas condensate fields.

Table 4 — Product streams

Product stream	Offshore platform	Onshore gas plant	Gas pipeline
LPGs		✓	
Natural gas liquids	✓	✓	
Wet gas or export gas	✓	✓	✓
Sales quality gas	✓	✓	✓
LNG		✓	
Fuel gas	✓	✓	✓
Flare gas	✓	✓	✓
Import gas	✓		✓
Re-injection gas	✓		
Produced water	✓	✓	
Re-injection water	✓		
H ₂ import		✓	✓
CO ₂ import/ export		✓	✓

4.8.3 Input streams

Depending on the case, input streams can be:

- well productions;
- well hookup, platforms, flow lines, risers' exports;
- fields exports;
- pipeline inputs;
- terminal inputs;
- any other gas or liquid inputs into systems.

4.8.4 Fluid characteristics

Whatever fluids are multiphase, wet gas or single phase, quantities measured or determined at actual conditions shall be converted at standard conditions. Fluid behaviour versus pressure and temperature and specifically fluid change from measurement conditions to reference conditions shall be recorded.

More details on fluid types and behaviour are given in [Clause 5](#).

4.8.5 Gas and liquid compositions

There are a variety of fluid compositions depending on the type of stream. Stream compositions can consist of several hydrocarbon components such as methane, ethane, propane, butane, pentane, hexane, heptane and heavier components as well as non-hydrocarbons components such as CO₂, H₂, N₂, H₂O, H₂S, etc.

In allocation calculation, components are referred and indexed with C₁, C₂, C₃, iC₄, nC₄, iC₅, nC₅, C₆ and so on up to C_n. Combinations of components with higher hydrocarbons numbers than C₆ are referred to as C₆₊ or C_{n+}.

4.9 Allocation process

For a given allocation perimeter, a standard allocation process generally involves the following tasks which concern both measurements as well as specific allocations items:

- well measurements (well test, wellhead measurements);

- stream flow measurements, including, when possible, condition-based monitoring;
- stream sampling and analysis, calculations at the measurement points for the incoming and outgoing streams;
- possible corrections on flow measurements: correction factors;
- balancing and reconciliation between the incoming and outgoing amounts (losses);
- utilities allocation, like fuel consumption and gas lift;
- disposal allocation;
- inventory calculation and allocation if needed;
- calculation of user's/owner's share in the comingled outgoing stream based on the allocation method;
- official reporting.

4.10 Gas allocation cases summary

The typical gas products to allocate per system are summarized in [Table 5](#).

Table 5 — Gas allocation matrix

	Gas	HC liquid	Water	Dry gas	Sales gas	LPG	LNG	Condensate	H ₂	H ₂ S	CO ₂	Fuel and flare
Wellhead platform	X	X	X									X
Processing facilities	X	X	X	X				X				X
Pipeline				X	X			X	X		X	X
Terminal					X	X		X			X	X
LNG plant						X	X	X			X	X

4.11 Allocation methodology

Methods of allocation are generally classified in four groups as per Reference [\[29\]](#):

- a) allocation by pro-rata;
- b) allocation by difference;
- c) allocation by process simulation with flash calculations;
- d) uncertainty-based allocation.

Detailed descriptions are given in [Clause 7](#).

The methods can be performed in energy, mass or volume. Allocation based on energy or mass by hydrocarbon components are the most comprehensive. If allocation by volume is used for well back allocation for reservoir monitoring purposes, it is generally not recommended for fiscal allocation but can be accepted when allocation by mass is not possible or the products or energy has minimal affiliation. An example is utility gas allocation, where mass measurement nor representative sampling of the flare is possible. If the flare gas is a small share of the utility gas consumption, it can be assumed that the flare gas composition is equal to the fuel gas composition or an agreed density can be used to convert volume to mass.

4.12 Balance and reconciliation

4.12.1 Balance

In an ideal system, receiving and exporting flows with no losses, on a given period, shall balance as per [Formula \(1\)](#).

$$I + I_S = O + C_S \quad (1)$$

where

I is inputs;

I_S is initial stocks;

O is outputs;

C_S is closing stocks.

The imbalance I_B calculated as per [Formula \(2\)](#):

$$I_B = \sum x_{OUT} + s_{t2} - (\sum x_{IN} + s_{t1}) \quad (2)$$

where

s_{t2} is the stock at time, $t2$;

s_{t1} is the stock at time, $t1$ with $t2 > t1$.

shall equal to 0.

Imbalance other than 0 indicate either loss/gain or measurement issues. Ideally, material conservation shall be achieved with $I_B = 0$.

Imbalance is an indicator used to track the difference between the sum of all inputs and outputs of a production system corrected by stocks/inventory changes prior to allocation.

A significant imbalance I_B can indicate measurement errors/discrepancies or losses.

In all cases, imbalances calculations should be carried out over a representative period to check ins equal to outs. Inventory change shall be considered in imbalances determination.

Material imbalances calculation is carried out on a volume, mass, molar or energy basis, depending on the allocation type and the measurement system as well as analysis availability.

The advantages and disadvantages of the most common methods are summarized in [Table 6](#). (From Reference [\[12\]](#).)

Although volume balancing has several disadvantages (principally, the complexity of conserving a material balance), it is widely used as many stream measurements are made using volumetric meters. Also, for historical reasons, reports are frequently requested in volume units (e.g. barrel of oil or standard cubic foot of gas).

Table 6 — Advantages and disadvantages of allocation balance basis

	Mass balance and component mass balance	Component molar balance	Volume balance	Energy balance
Advantages	— A mass-balanced system is easy to understand.	— A molar balanced system is easy to understand.	— Volume is simple and easy to understand.	— Allows swapping of components between product streams. This can enhance the flexibility of the allocation system, e.g. if one user prefers gas and another prefers NGL.
	— Mass is not affected by phase change.	— Molar quantities are not affected by phase change.	— Volume measurement is a common method for metering oil and gas.	
		— Gas analyses are typically in mole per cent.	— Industry uses volume for routine reporting of production reporting and reserves	
Disadvantages		— Molar compositions are required if flash calculations are to be performed.		
	— Direct mass measurement is not widely used. It is therefore generally necessary to convert from volume measurement, which requires composition, pressure and temperature data	— Molecular weights of non-standard components can be unknown.	— Volumes are not additive so they are not normally conserved across a process. This is because volumes:	— Calculations require composition data for all streams.
		— Molar measurement (stream compositional analysis) is often not known.	a) change with pressure and temperature;	— Details of individual components are lost.
			b) change with phase changes.	— The value of components is not correctly recognized e.g. propane in a liquid stream has a different financial value than propane in a gas stream.
			— Accurate pressure and temperature data are required at all measurement points to allow calculation of standard volumes.	
			— Differing standards can cause confusion.	
			e.g. stock tank conditions and standard conditions are not the same.	

4.12.2 Reconciliation

Whichever allocation method or combination of allocation methods is selected, an overall material balance across the system shall be established. Due to uncertainties in measurements and estimates, it is unlikely that the sum of input quantity equals the sum of products.

Reconciliation is a mathematical process to ensure consistent input and output flows satisfy the material balances.

Standard reconciliation practice is to normalize inputs data to match output quantities. This is because outputs are generally measured accurately and are considered official.

Reconciliation is achieved mathematically by performing a simple pro rata method assuming the output stream is the correct value. See [Figure 4](#), which represents oil reconciliation for field allocation.

Outputs are considered correct. Imbalance is distributed based on contributions.

Some systems can use redundant data. For example, an onshore gas plant can measure flow and composition of all the feed streams and of all the product streams. However, due to measurement uncertainties, the total feed is unlikely to equal the total products. In this event, the more uncertain measurements are reconciled to the less uncertain measurements. Normally, the feed streams are reconciled to match the product streams.

For modern flow meters, condition-based monitoring techniques, i.e. online diagnostic tools, can reduce the likelihood of any flow measurement bias going unnoticed.

Reconciliation is then performed using flow data uncertainty and optimization algorithms thanks to data validation reconciliation approaches in which input and output flow data are adjusted to satisfy mass balance equation.

This type of method, which can be used to detect errors, can be used internally to ensure the data sets are consistent and the balances are closed prior to allocation.

Redundant data can be useful as they can reduce the uncertainty in the data that are used.

4.13 Units

In this document, SI units are used as well as the following:

- pressure is expressed in bar absolute or bar units¹⁾;
- volume is expressed in Sm³ at standard conditions (at 15 °C and 1 atmospheric pressure).

Allocation may be conducted in mass (kg), since mass is not influenced by pressure and temperature to the same extent as volume. Mass calculation has less uncertainty.

It can be necessary to express gas volumes in oil equivalent (O_E). In the absence of any other specific formula, the following conversion can be used:

$$1 \text{ m}^3 \text{ O}_E = 1\,000 \text{ Sm}^3 \text{ gas @ } 40 \text{ MJ/ Sm}^3$$

4.14 Upstream allocation example

An example of an upstream allocation is shown in [Figure 4](#). The asset has four tie-in fields/streams to a common process facility. Allocation can be conducted using pro-rata calculations, by difference calculation or simulation. The calculation can be in units for mass, energy or volume. The measurement can be executed on single or multi-phase fluid at different rates.

NOTE Representative flow proportional sampling is only obtainable for single phase fluids.

1) 1 bar = 0,1 MPa = 10⁵ Pa; 1 MPa = 1 N/mm².

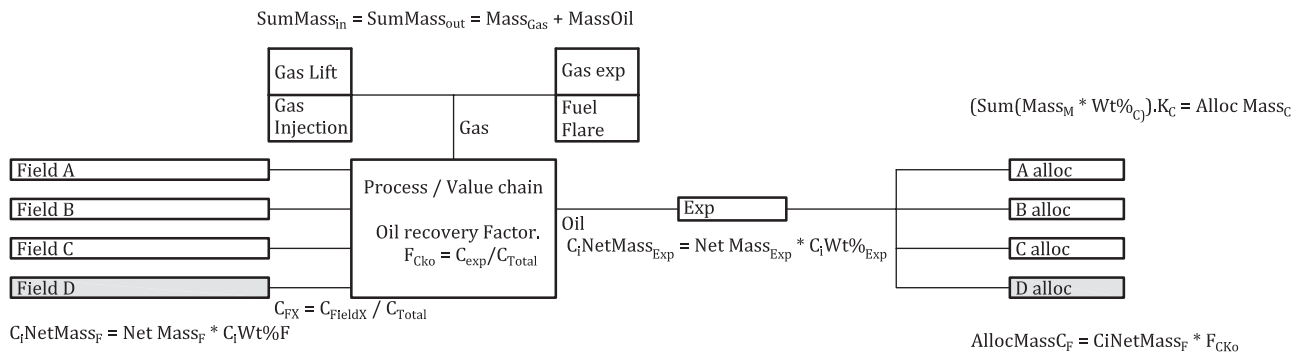


Figure 4 — Upstream allocation example

4.15 Contractual gas allocation

4.15.1 General

Prior to entering gas allocation system negotiations, the underlying framework of commercial agreements (either existing or being negotiated) and the technical characteristics of the production system, pipeline and terminal shall be known. For example, each system user's perception of the local gas 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:
 - 1) allocation and attribution period set to one day;
 - 2) limited re-nomination with relatively long lead times;
 - 3) priority system for the attribution process;
 - 4) mechanisms for notified and system substitution;
 - 5) 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:
 - 1) allocation period set to less than one day;
 - 2) relatively short re-nomination lead times;
 - 3) no priority system with the allocation process;
 - 4) no gas substitution;
 - 5) all nominations and re-nominations treated as firm;
 - 6) line pack controlled by the system users;
 - 7) within a day production changes to supplement gas delivery.

The specific situations are never as clear-cut as outlined above. 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 negotiations, it is likely that the allocation system does not fulfil the system users' requirements and objectives. In extreme cases, the poor quality of the allocation system can impinge on the operation of the offshore production facility and/or 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. The following issues shall be considered:

- Is the gas being sold to individual 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 the 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?
- How flexible is the production system to respond to required changes in flow rate?
- Are there any local statutory regulations/considerations with respect to measurement devices, reporting and/or gas balancing?

4.15.2 Gas-allocation issues

From a technical standpoint, developing a gas-allocation system shall include all aspects of the overall process design and operation. This includes the implications of variations in processing conditions and gas compositions on the terminal product. From a commercial standpoint, gas allocation system development shall be consistent with the gas sales agreements and the overall commercial structure.

By its very nature, a gas-allocation system encompasses a wide range of topics. These include:

- measurement methods;
- flow meter validation and diagnostic suites;
- 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 document.

4.15.3 Measurement

Measurement includes metering and sampling. Measuring 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 of the different types of metering systems, sampling equipment and associated analytical techniques is required. 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. Flow meters can have condition-based monitoring, i.e. online diagnostic tools, that indicate if the meter is operating correctly or if it malfunctions.

The specification of metering and sampling equipment at each measurement point should be designed in accordance with applicable standards and local regulations. Commercial considerations can have an impact on this specification. For example, it can be agreed that a marginal field can 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 exits 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.

4.15.4 Terminal products

Terminal products relates to the onshore processing of the commingled gas stream 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 entitlement.

4.15.5 Pipeline capacity

Pipeline capacity relates to the steady-state and transient operation of the gas pipeline. The allocation procedures shall not inhibit pipeline operation and vice versa.

4.15.6 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 need to ensure that the process reflects the dynamics of the system.

4.15.7 Agreements

4.15.7.1 Gas sales agreement

The gas sales agreement specifies the gas specification at the re-delivery point, nomination procedures, forecasting and gas measurement required. It 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.

4.15.7.2 Commercial agreements

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

4.15.8 Regulatory

4.15.8.1 Statutory obligations

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

4.15.8.2 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.

4.15.9 Commercial issues

4.15.9.1 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 shall be specifically 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.

4.15.9.2 Nomination

Nomination relates to the quantity of gas requested by a buyer from a system user for delivery from the terminal. The aggregate nominations of all system users (from a field) are used to establish the field's contribution of production into the pipeline system.

4.15.9.3 Substitution

Substitution is the mechanism that enables one user to lend or borrow gas (exported from the terminal) to/from another system user to meet either system user's nominations.

The difference between a field's allocated and attributed quantities is substitution. Substitution is a mutual self-help process that is controlled at the terminal by the terminal operator. The terminal operator is aware if a producing area is having difficulties meeting the production targets and can find another operating area that can contribute; and vice versa if a producing area can produce excess gas. Limitations can be imposed on the level of lending, borrowing and the payback period.

4.15.10 Time period

The time period relates to the allocation and attribution calculations. Consideration is given to daily, hourly or another allocation period. It is possible that the allocation period is not linked to the nomination period, e.g. when there is an hourly allocation period but a daily nomination period. In addition, there often exists downstream gas transporters "balancing" periods. This balancing period is the time frame within which the downstream gas transporter can levy penalties for imbalances between inflow and outflow, e.g. an hourly allocation period but a balancing period of 4 to 6 h. This gives the gas time to travel from the input point to the output point. The allocation period is shorter as this enables the shippers to manage their imbalance positions within the balancing period.

4.15.11 Forecasting

Forecasting ensures that the lead times for the provision of the data required by the gas sales agreements and the production and planning targets for the terminal and platform operators are incorporated.

4.15.12 Pipeline stock

Pipeline stock relates to the use of pipeline stock to help achieve gas delivery. It is necessary to consider which commercial party controls the level of stock in the pipeline, e.g. the pipeline/terminal operator or the system users.

4.15.13 Existing systems

The system shall seamlessly integrate with existing gas-allocation systems and with the existing procedure associated with existing downstream systems.

4.15.14 Data timing

Data timing ensures that nominations and any potential re-nominations within the allocation agreement coincide with the requirement of the gas sale agreements and operational requirements.

4.15.15 Data flow and reporting

Evaluating data flow and reporting ensures that sufficient information is provided to check the allocation and attribution reports prepared by the system operator. Where individual parties receive data, all parties shall receive the same information at the same time. Business processes are required for the terminal operator to advise the field operators to increase/decrease the flow of production into the pipeline system.

4.15.16 Auditing

Auditing provides a means of checking the overall operation of the system operator if errors are found within the allocation statement. This issue shall be a priority item within any allocation-agreement negotiations.

4.15.17 Fallback

A detailed fallback plan establishes how nominations and data flow are provided if the normal communication processes fail or meter data do not exist.

4.15.18 Summary

The results from allocation calculations establish each participant's revenue from the system. A gas-allocation agreement is not a technical agreement. During the negotiation of an allocation, system users should be wary of statements that imply that the allocation agreement is purely a technical arrangement and, hence, should be developed by the technical departments.

In conclusion, when gas from two or more entry sources are commingled and processed in a common pipeline and terminal system and the sources have different ownership and/or operate under different tax regimes, a gas-allocation system is required. The allocation system shall 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.

The following should be considered:

- a) All allocation procedures are unique and are specifically designed for a given system driven by commercial considerations.
- b) For an allocation system, technical solutions are developed to meet the specific commercial requirements.
- c) There is no standard allocation procedures but there are standard elements and approaches that combine to produce the overall allocation system.
- d) As with any other commercial agreement, allocation agreements are finalized because of negotiation and compromise. It is therefore not good practice to take an existing agreement and attempt to modify it without discussing the terms of the agreement with the parties that negotiated it.

- e) It is necessary that an allocation/attribution system is not developed in isolation from other commercial agreements, e.g. transportation and operating agreements.

5 Fluid property and parameters for allocation

5.1 Fluid types

In gas facilities, the fluid can be multiphase, wet gas or single phase.

Fluid behaviour (specifically how the fluid changes from measurement conditions to reference conditions) against changes in pressure and temperature shall be used to calculate allocation parameters and convert the quantities measured or determined at actual conditions in standard conditions.

Unsaturated (or stabilized) and saturated (non-stabilized) fluids and gases shall be distinguished.

[Table 7](#) illustrates types of fluids per locations and products.

Table 7 — Typical fluid types per streams and products

	Multiphase	Single phase	Unstabilized	Stabilized
Input streams				
Well productions	x	x	x	
Field productions	x	x	x	x
Pipeline inputs	x	x	x	x
Terminal inputs	x	x	x	x
H ₂ import		x		x
Import gas/water		x		x
Diluent		x		x
Gas lift		x		x
CO ₂ import		x	x	x
Products				
Oil export		x	x	x
Sales oil and condensate		x		
LPGs		x	x	
Export gas including C ₂ , C ₃		x		x
Sales gas		x		x
LNG		x	x	
Fuel gas		x		x
Flare gas		x		x
Gas injection		x		x
Produced water		x		x
Water disposal	x	x		x
Water injection		x		x
CO ₂ export		x	x	x
H ₂ export		x		x

5.2 Gas and liquid properties

5.2.1 General

Thermodynamic properties (e.g. composition, density, phase fractions) and fluid characteristics (e.g. viscosity) shall be used to determine flow rates from primary measurements (e.g. velocity, pressure drop, attenuation, frequency, absorption).

In [7.1](#), the calculation method is addressed for use when fluid properties and/or composition:

- change with pressure and temperature;
- are not measured or cannot be measured directly.

At the conditions prevailing at the measurement point, streams can be stabilized (gas phase or liquid phase) or non-stabilized either as one phase (gas or liquid) or as two phases (gas and liquid).

5.2.2 Stabilized fluids

For stabilized gases, calculation routines to derive density and compressibility factors are based on existing standards such as ISO 6976 using composition, pressure and temperature to derive density and compressibility factors.

For density and compressibility factors of liquid, API or ISO standards API MPMS Chapter 11 or ISO 91 may be used if applicable.

5.2.3 Equilibrium gas (separated gas at dew point)

Equilibrium gas is defined as separated gas that has no free liquids but can develop a small liquid content by changes in process conditions or meter/pipe-work interaction. Any process changes of the gas can cause a shift in the definition of the gas as wet or dry.

The measurement devices that can be used for equilibrium gas are like the devices mentioned for dry gas application. However, in the design, care should be taken that as soon as liquids start to form (e.g. due to pressure drop in the meter), the effect on the reading should be established.

5.2.4 Equilibrium liquid (separated liquid at bubble point)

Equilibrium liquid, i.e. liquid from a separator at its bubble point, in principle contains only liquid. However, small amounts of gas can break out in situations where a pressure drop is encountered (e.g. valves or metering equipment). This condition occurs when the head pressure has been sufficiently reduced or the temperature increased to cause gassing-off or boiling of the fluid. This gas breakout usually gives rise to measurement errors if single-phase liquid meters are used. Measurements of these fluids require care and attention in view of the pipe geometry and line sizes to ensure that the liquid is below its bubble point at the measurement point. Meter shall be selected and pressure drop should be minimized to prevent meter performance degradation.

5.2.5 Flash calculations for non-stabilized and wet gas flows

For non-stabilized fluids including two-phase flows, such as wet gas, gas and liquid composition and properties shall be determined indirectly by flash calculations.

Flash calculations can be performed on-line or off-line using specific pressure, volume, temperature (PVT) software or a process simulator. If flash calculations are performed off-line and are complex, flash interpolation tables or equations can be generated and downloaded in flow computers or in any digital control system.

As an example, such tables can be two-dimensional tables containing values of density, liquid fractions for a specific well or field composition at specific values of temperature and pressure. For each composition, a flash table or equation can be generated.