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LNG CUSTODY TRANSFER HANDBOOK

6TH EDITION

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GIIGNL

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01

Introduction

GIIGNL - THE INTERNATIONAL GROUP
OF LIQUEFIED NATURAL GAS IMPORTERS

LNG CUSTODY TRANSFER HANDBOOK

6th Edition: 2021

INTRODUCTION TO THE CTH

This handbook serves as a reference manual for the **determination of the energy quantity of LNG transferred** between LNG ships or LNG trucks and LNG Terminals

Is no standard and no specification

But sets out the practical issues and requirements to work out a suitable procedure for a specific LNG ship-shore and truck custody transfer application

LNGVaporizer
Calibration
AnalysisReport
Gassing-up
VolumeMeasurement
TemperatureMeasurement
EnergyTransferMeasurement
Gasanalysis
Cool-down
EnergyConsumed
Impurities
Density
GrossCalorificValue
SamplingOfLNG
GaugeTables
Reloading
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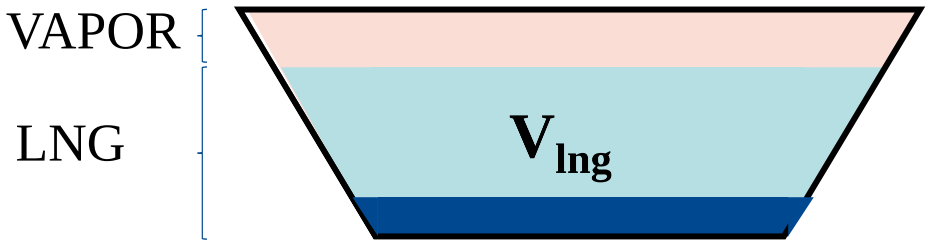
02

Determination Energy Transferred

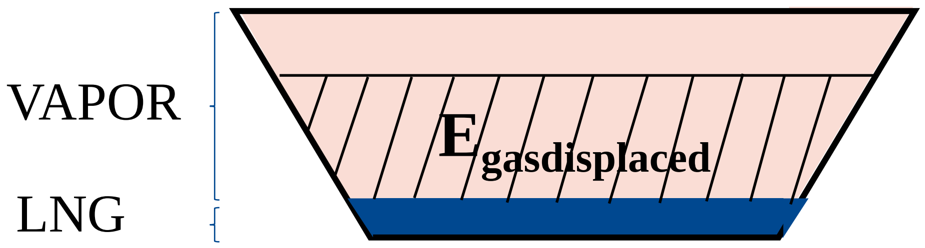
CALCULATION ENERGY TRANSFERRED

Unloading operation

Before unloading:



After unloading:



$$E = V_{lng} * D_{lng} * GCV_{lng} - E_{gasdisplaced} - E_{gas\ to\ engine\ room}$$

Where:

E = Total net energy transferred (MMBTU or MWh)

V_{lng} = The volume unloaded (m³)

D_{lng} = The density of LNG unloaded (kg/m³)

GCV_{lng} = The gross calorific value of the LNG unloaded (MMBTU/kg or MWh/kg)

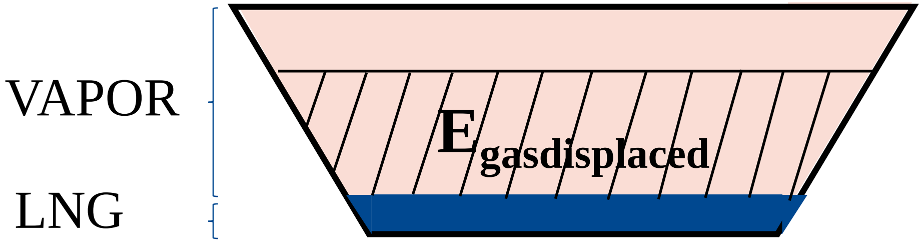
$E_{gasdisplaced}$ = The net energy of the displaced gas (MMBTU or MWh)

$E_{gas\ to\ engine\ room}$ = if applicable, the energy of the gas consumed in the LNG carrier's engine room (incl. GCU) (MMBTU or MWh)

CALCULATION ENERGY TRANSFERRED

Loading operation

Before loading:



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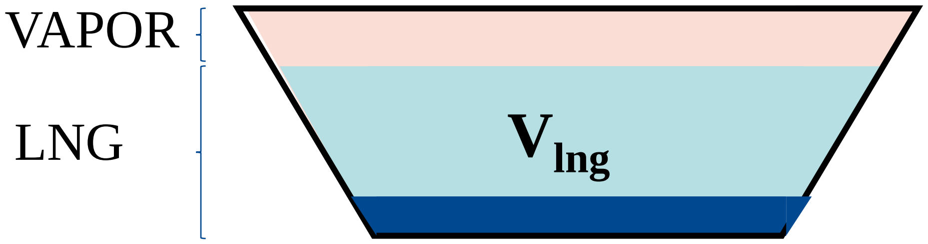


$$E = V_{lng} * D_{lng} * GCV_{lng} - E_{gasdisplaced} + E_{gas\ to\ engine\ room}$$

Where:

E = Total net energy transferred (MMBTU or MWh)

V_{lng} = The volume loaded (m³)

D_{lng} = The density of LNG loaded (kg/m³)

GCV_{lng} = The gross calorific value of the LNG loaded (MMBTU/kg or MWh/kg)

$E_{gasdisplaced}$ = The net energy of the displaced gas (MMBTU or MWh)

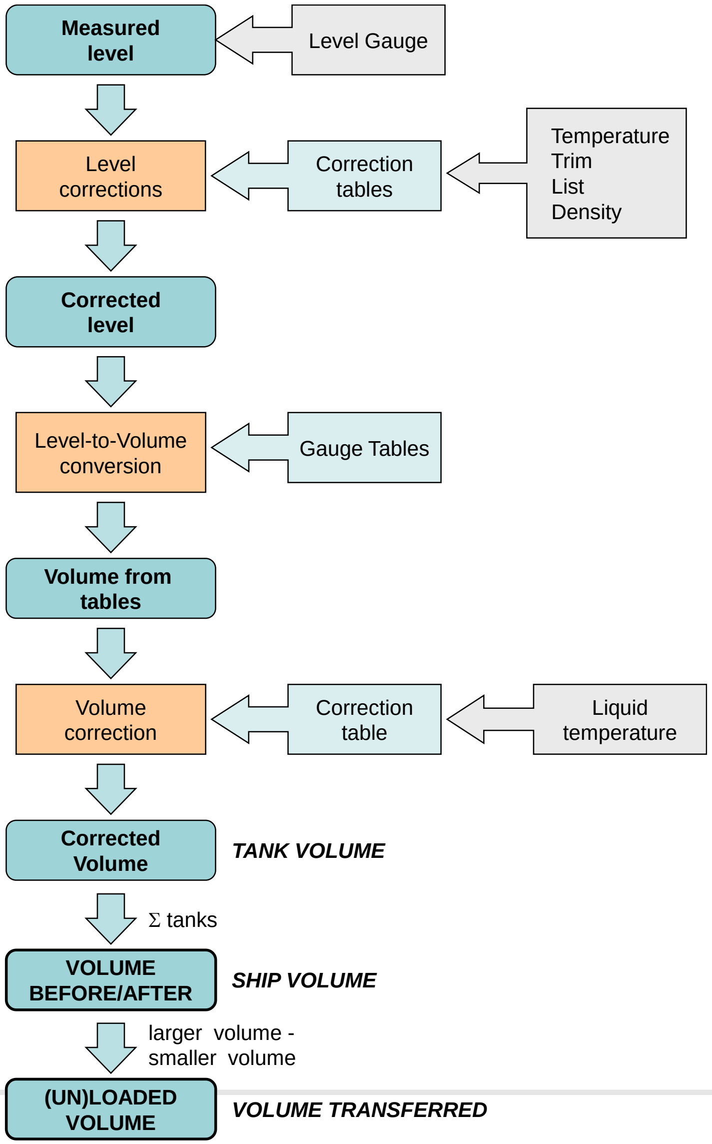
$E_{gas\ to\ engine\ room}$ = if applicable, the energy of the gas consumed in the LNG carrier's engine room (incl. GCU) (MMBTU or MWh)

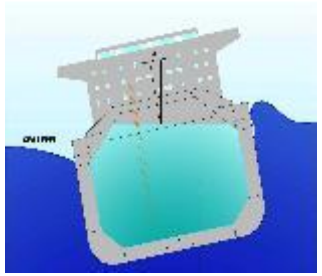
CALCULATION OF ENERGY TRANSFERRED

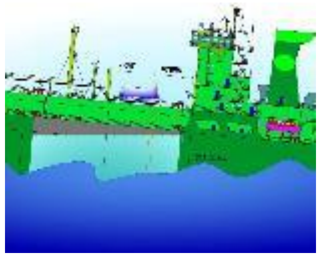
LNG Volume

LNG Volume

- Equipment for measuring the level of LNG in the LNG carrier’s tank:
  - Each cargo tank has two level gauge systems installed (primary and secondary)
  - Typically radar as primary and floating as secondary
- LNG carrier’s calibration tables, including main gauge tables and correction tables
- Temperature probes distributed over the height of the LNG carrier’s tanks
- Custody Transfer Measurement System (CTMS)
  - LNG carrier fitted with an automatic system for the calculation of LNG and gas volume in each tank







CALCULATION OF ENERGY TRANSFERRED

LNG Volume

LNG CARRIER
VOYAGE No.
CARGO DENSITY: 450.90 kg/m^3
TRIM: +50 cm (AFT)
LIST ANGLE: 0 °
BERTH:

CARGO ON BOARD AT DEPARTURE
SURVEY DATE:
SURVEY TIME GMT:
LOCAL TIME:
REMARKS:

	Vapor temp. °C (1)	Level gauge reading mm	Corrections					Corrected height mm (7)	Liquid Volume m^3 (8)
			Shrink. mm (2)	Density mm (3)	List mm (4)	Trim mm (5)	Overall mm (6)		
TANK 1	-152.00	22 040	1	2	0	-19	-16	22 024	12 833.320
TANK 2	-152.00	22 123	1	2	0	-32	-29	22 094	26 364.256
TANK 3	-152.00	22 138	1	2	0	-35	-32	22 106	29 914.104
TANK 4	-156.00	22 165	1	2	0	-35	-32	22 133	29 962.222
TANK 5	-156.00	22 150	1	2	0	-34	-31	22 119	25 210.599
						TOTAL O/B dep.			124 284.501
						TOTAL O/B arr.			2 250.172
			% Cargo on board: 98			TOTAL loaded			122 034.329

CALCULATION OF ENERGY TRANSFERRED

LNG density

LNG density

- Determination on the basis of the average composition of the LNG obtained by:
  - Continuous or discontinuous sampling and analyse in laboratory or
  - Gas chromatographic analysis.

- Calculation based on the average composition, average temperature and coefficients.
  - A variety of calculation methods exists,
  - In this handbook the preferred method is the revised Klosek-Mckinley (ISO6578)

CALCULATION OF ENERGY TRANSFERRED

LNG gross calorific value

LNG gross calorific value

- Determination on the basis of the average composition of the LNG obtained by:
  - Continuous or discontinuous sampling and analyse in laboratory or
  - Gas chromatographic analysis
- Calculation based on the average composition and characteristics of elementary components (GCV, molar volume, molar weight) given by reference tables or standard for the gross calorific value.
- Reference conditions:
  - For determination of GCV: t = 0°C, 15°C, 15.56°C (60°F), 20°C or 25°C
  - For determination of volume:
    - p = 1.01325bara (14.696psia) or, sometimes, 1.01560bara (14.73psia)
    - t = 0°C, 15°C, 15.56°C (60°F), 20°C or 25°C

CALCULATION OF ENERGY TRANSFERRED

LNG gross calorific value

Component		Molar fraction	Molecular weight component	Molecular weight fraction	GCV component	GCV fraction kJ/mol
		(1)	(2) g/mol	(3)=(1).(2) g/mol	(4) kJ/mol	(5)=(4)-(1) kJ/mol
Methane	CH_4	0.89235	16.04246	14.315971	891.51	795.53895
Ethane	C_2H_6	0.08267	30.06904	2.485808	1 562.14	129.14211
Propane	C_3H_8	0.01313	44.09562	0.578975	2 221.10	29.16304
Isobutane	iC_4H_{10}	0.00167	58.12220	0.097064	2 870.58	4.79387
n-Butane	nC_4H_{10}	0.00277	58.12220	0.160998	2 879.76	7.97694
Isopentane	iC_5H_{12}	0.00011	72.14878	0.007936	3 531.68	0.38848
n-Pentane	nC_5H_{12}	0.00000	72.14878	0.000000	3 538.60	0.000000
Nitrogen	N_2	0.00730	28.01340	0.204498	0.00	0.000000
SUM		1.00000		17.850769		967.00339

CALCULATION OF ENERGY TRANSFERRED

Energy of the displaced gas

Energy of the displaced gas

- Formula:

$$E_{gas\ displaced} = V_{LNG} \frac{273.15}{273.15 + T} \cdot \frac{p}{1.01325} \cdot GCV_{gas}$$

- Composition can be determined from:
  - Sampling of the gas displaced and analysis or
  - A gas chromatographic analysis or
  - Assumed to be a fixed mixture of nitrogen and methane, or pure methane.

- Volume of displaced gas = Volume LNG (un)loaded

- Pressure and temperature measurements within the LNG carrier’s tank

CALCULATION OF ENERGY TRANSFERRED

Energy of "gas to engine room"

Energy of "gas to engine room"

- Formula:

$$E_{fuel\ gas} = V_g . GCV_{gas}$$

- Composition can be determined from:
  - Sampling of the gas displaced and analysis or
  - A gas chromatographic analysis or
  - Assumed to be a fixed mixture of nitrogen and methane, or pure methane

- Volume of fuel gas = is the volume measured by flow meters

- Pressure and temperature measurements within the LNG carrier's tank

CALCULATION OF ENERGY TRANSFERRED

Sampling of LNG

Continuous sampling:

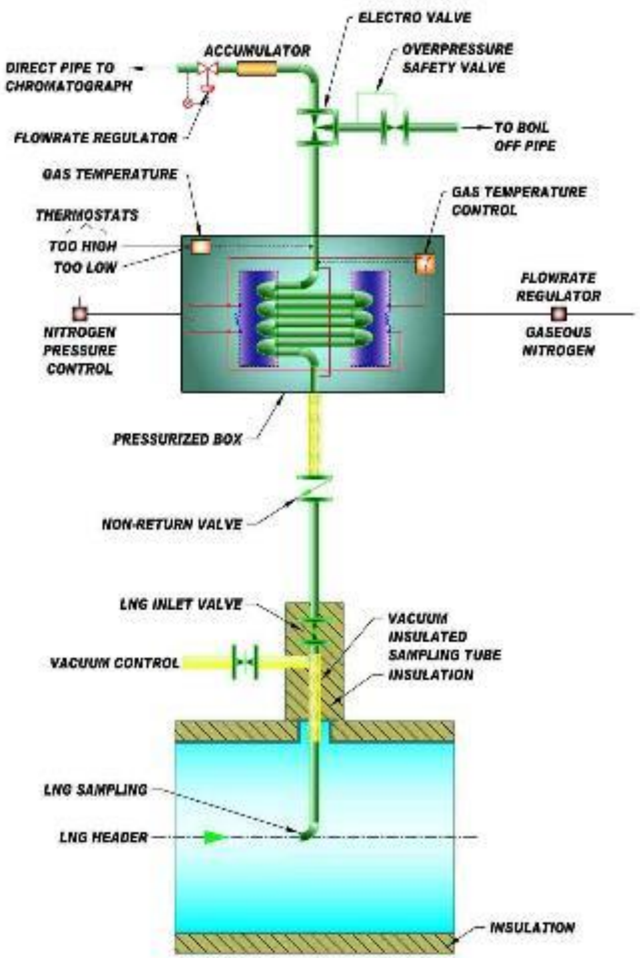
- Continuous collection of LNG from the LNG flow line,
- Regasification LNG sample,
- Sample holder
- Representative composition of the full operation

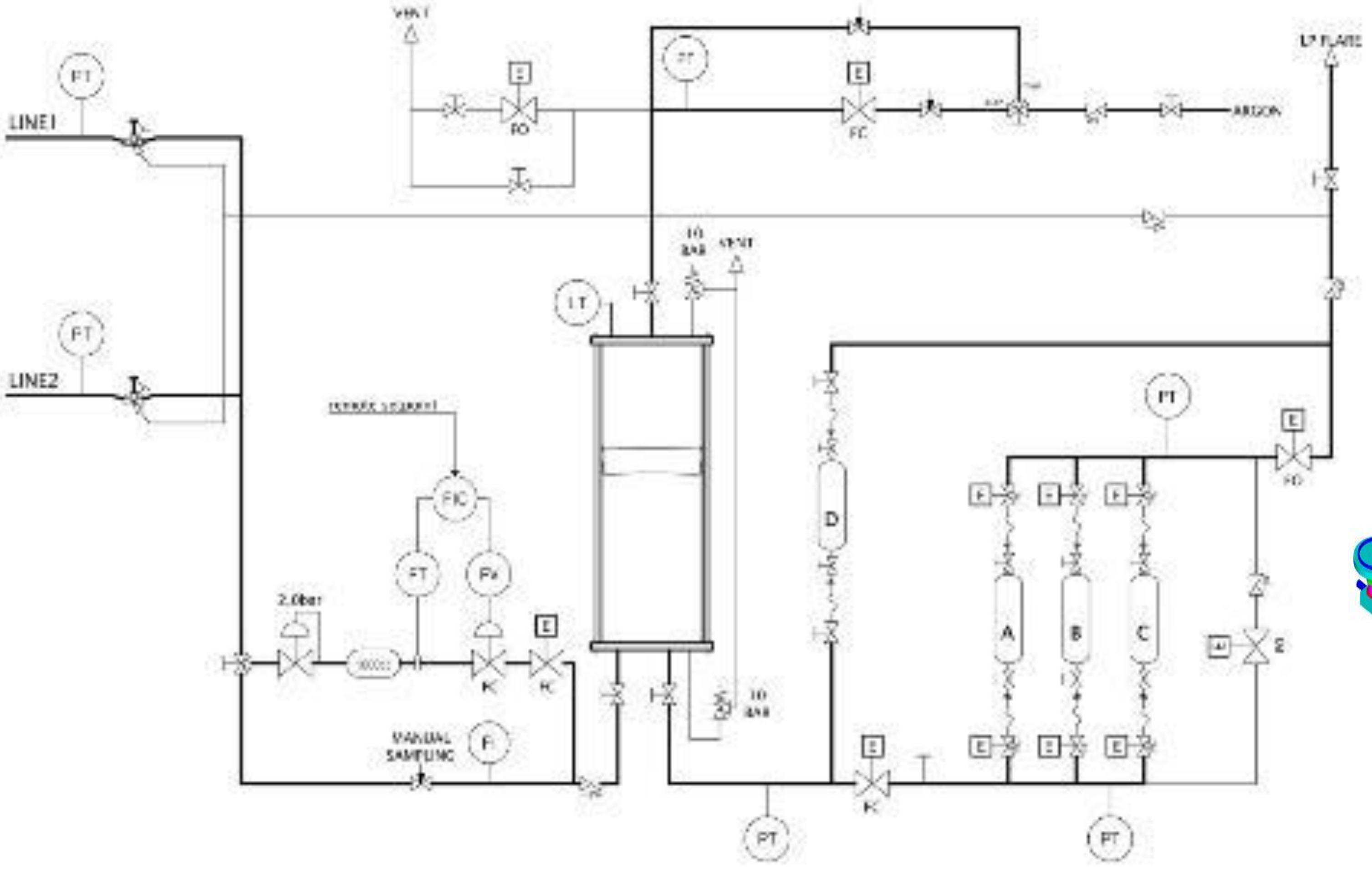
Discontinuous sampling:

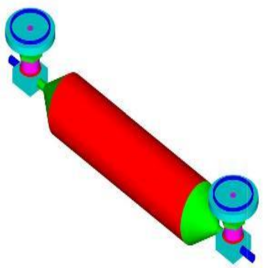
- Discontinuous sampling,
- Regasification LNG sample,
- Directed to an on-line GC
- Data treatment
  - Statistical test for each analysis and each LNG component,
  - Elimination of the detected outliers,
  - Calculating the average composition,
  - Normalizing the final LNG composition

CALCULATION OF ENERGY TRANSFERRED

Sampling of LNG



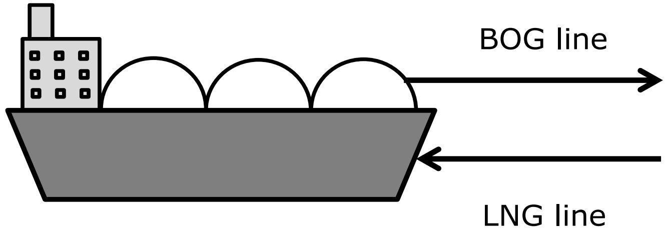




CALCULATION OF ENERGY TRANSFERRED

Alternative method for loading operations

- Determine the volume transferred instead of using the cargo tank tables



- *Formula:* $E = E_{LNG\ line} - E_{BOG\ line}$
- Mass or flow meters are installed in both LNG and BOG lines
- Small scale
- Correction of LNG flashing: LNG sampling are made in the LNG transfer line(s) prior to possible flashing in the ship's cargo tanks. If flashing occurs in the ship's cargo tanks, then this causes a minor change in LNG composition

03
What's new

CALIBRATION AND VERIFICATION GC

Calibration and verification GC

Verification: verification of the relationship between reference gas and instrument response

Calibration: establish relationship between calibration gas and instrument response (peak area)

Two possible calibrations:

- Multi-point calibration (does not involve non-linearity errors)
- Single-point calibration (involves non-linearity errors)

Calibration gas:

- Close match to the expected LNG quality
- Higher quality than the verification gas

LOADING OF LNG TRUCKS

Introduction

No internationally accepted design standards

Cryogenic hoses or hard arms

Use of weighbridge or flow measurement

Loading operation:

- In case of the use of vapor return, decompression of the LNG truck.
- An initial period, corresponding to the starting of loading where the LNG flowrate is low (cooldown).
- An increase of LNG flowrate until the nominal flowrate (ramp-up).
- A stable period at the constant nominal flowrate (loading).
- A final period when LNG flowrate begins to decrease before stopping completely (ramp-down).

LOADING OF LNG TRUCKS

Energy determination

Static measurement (weighbridge):

Formula: $E = M_{LNG} * GCV_{LNG}$

Where:

E = Total net energy transferred from the Terminal to the LNG truck (kWh or MMBTU)

M_{lng} = The mass of LNG loaded (kg)

GCV_{lng} = The gross calorific value of the LNG loaded (kWh/kg or MMBTU/kg)

LOADING OF LNG TRUCKS

Energy determination

Dynamic measurement (flow measurement):

Formula: $E = (M_{LNG} * GCV_{LNG}) - E_{gas\ returned}$

Where:

E = Total net energy transferred from the Terminal to the LNG truck (kWh)

M_{lng} = The mass of LNG loaded (kg)

GCV_{lng} = The gross calorific value of the LNG loaded (kWh/kg)

$E_{gas\ returned} = V_{gas\ returned} * GCV_{gas\ returned}$ = The total net energy transferred from LNG truck to the Terminal (kWh)

OTHER MODIFICATIONS

Other modifications

- Update the source and the date of the source for all tables in the CTH
- Update the reference to standards
- Loading and unloading of one vessel with different LNG qualities
- Update the tasks of the independent surveyor
- Update with the new developments
- Correction errors

04

Q&A

THANK YOU

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