INTERNATIONAL STANDARD

ISO 7278-3

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Liquid hydrocarbons — Dynamic measurement — Proving systems for volumetric meters —

Part 3:
Pulse interpolation techniques

Hydrocarbures liquides — Mesurage dynamique — Systèmes d'étalonnage pour compteurs volumétriques —

Partie 3: Techniques d'interpolation des impulsions

Reference numbe
ISO 7278-3:1998(E)

Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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.

International Standard ISO 7278-3 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 2, *Dynamic petroleum measurement*.

This second edition cancels and replaces the first edition (ISO 7278-3:1986), which has been technically revised, in particular with addition of annex A and annex B.

ISO 7278 consists of the following parts, under the general title *Liquid hydrocarbons – Dynamic measurement – Proving systems for volumetric meters:*

— *Part 1: General principles*

— *Part 2: Pipe provers*

— *Part 3: Pulse interpolation techniques*

— *Part 4: Guide for operators of pipe provers*

— *Part 5: Small volume/compact provers*

Annex A forms an integral part of this part of ISO 7278. Annex B is for information only.

Introduction

The use of pipe provers to prove meters with pulsed outputs requires that a minimum number of pulses be collected during the proving period. The number of pulses which a meter can produce during a proving run is often limited to significantly less than 10 000 pulses. Therefore, in many applications some means of increasing the meter's resolution has to be found.

One way of overcoming this problem is to process the signal from the meter in such a way that the resolution of the meter is increased. This technique is known as pulse interpolation.

This part of ISO 7278 applies primarily to pipe provers, but it is not intended to restrict in any way the future development of different methods of pulse interpolation to this and other applications.

Liquid hydrocarbons — Dynamic measurement — Proving systems for volumetric meters —

Part 3:
Pulse interpolation techniques

1 Scope

This part of ISO 7278 gives guidance on the procedures and conditions of use to be observed if pulse interpolation is used in conjunction with a pipe or small volume prover and a turbine or displacement meter to improve the discrimination of proving.

This part of ISO 7278 describes the three methods of pulse interpolation most commonly used and their conditions of use. It also describes the equipment and test procedures for checking that the pulse interpolation system is operating satisfactorily and it describes some methods of measuring the irregularity of pulse spacing for a meter.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 7278. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 7278 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6551:1982, *Petroleum liquids and gases – Fidelity and security of dynamic measurement – Cabled transmission of electric and/or electronic pulse data*.

3 Definitions

For the purposes of this part of ISO 7278, the following definitions apply.

3.1 clock: Device for generating a stable frequency, the period of which is used as a standard reference for time measurements.

3.2 detector signal: Contact closure or voltage change that starts or stops the indicating device.

3.3 intra-rotational linearity: Quantitative measure of the degree of regularity of spacing between the pulses, produced by a rotating meter at constant flowrate, generally expressed as the standard deviation of pulse spacing about the mean pulse spacing. This measure will include cyclic and non-cyclic measurements introduced by the meter mechanism. The pulse spacing is the time between the leading or lagging edges of consecutive pulses.

NOTE — Intra-rotational linearity is the regularity measurement which repeats in a periodic or cyclic manner attributed to the rotation of the meter.

3.4 leading/lagging edge: Rising or falling voltage of a pulse used to trigger or gate a counter.

3.5 phase detector: Electronic circuit which detects a phase difference between two pulse frequencies.

3.6 ramp generator: Electronic circuit whose output voltage varies linearly with time.

NOTE — Non-linear ramp generators are not used.

3.7 repeatability (of measurement instrument)**:** Closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions of measurement [VIM].

NOTE — The defined conditions of use are usually as follows:

- repetition over a short period of time;
- use at the same location under constant ambient conditions;
- reduction to a minimum of the variations due to the observer.

3.8 resolution: Quantitative expression of the ability of an indicating device to distinguish meaningfully between closely adjacent values of the quantity indicated [VIM].

3.9 rotating meter: Meter, the measuring element of which has one or more rotating parts driven by the flowing fluid (e.g. turbine meters and displacement meters).

NOTE — For the purposes of this part of ISO 7278, the output from the meter should be in the form of electrical pulses, the mean frequency of which is a function of the flowrate.

4 Principles

4.1 General

The following points are applicable when using any of the three techniques of pulse interpolation described in this part of ISO 7278.

a) The use of pulse interpolation is based on the assumption that there is no significant variation in the frequency of the pulses. Any variations in frequency caused by flowrate (see 5.1c)), or especially by intra-rotational non-linearity (see clause 6) will degrade the accuracy.

b) The interpolated number of pulses n' as described in 4.2, 4.3 and 4.4, will not generally be a whole number.

Multiple pulses from a flowmeter may be generated during a revolution of the meter, or to reduce intra-rotational non-linearity a single pulse per revolution may be used.

4.2 Double-timing method

See figure 1.

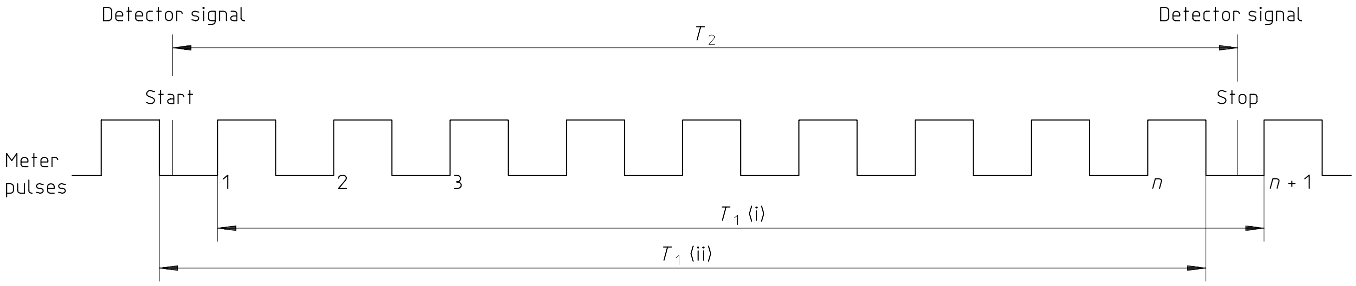
The principle of operation of this method is shown in figure 1. It consists of collecting, in a counter, the total number of complete meter pulses, n, generated during a proving run, and measuring two time-intervals, T_1 and T_2.

a) T_1 is the time-interval between the first meter pulse following the first detector signal and the first meter pulse following the last detector signal;

b) T_2 is the time-interval between the first and last detector signals.

The interpolated number of pulses is then given by

$$n' = n \frac{T_2}{T_1}$$



Interpolated number of pulses, $n' = n \dfrac{T_2}{T_1(\text{i})}$ or $n' = n \dfrac{T_2}{T_1(\text{ii})}$

Figure 1 — Double-timing method

4.3 Quadruple-timing method

See figure 2.

The principle of operation of this method is shown in figure 2. It consists of collecting, in a counter, the total integral number of pulses, n, generated during a proving run and measuring four time-intervals, t_1 to t_4.

a) t_1 is the time-interval between the first detector signal and the first meter pulse following that signal;

b) t_2 is the time-interval between the last meter pulse before the first detector signal and the first meter pulse after it;

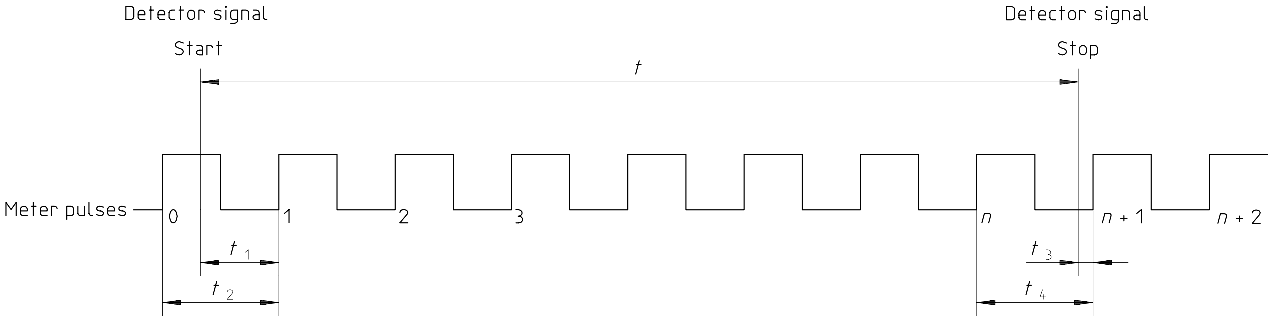
c) t_3 is the time-interval between the second detector signal and the first meter pulse following that signal;

d) t_4 is the time-interval between the last meter pulse before the second detector signal and the first meter pulse after it.

The number of complete pulses, n, in the main pulse count is counted in the normal way by a counter gated by the detector signals.

The interpolated number of pulses, n', between the detector signals is then

$$n' = n + \frac{t_1}{t_2} - \frac{t_3}{t_4}$$



Interpolated number of pulses, $n' = n + \dfrac{t_1}{t_2} - \dfrac{t_3}{t_4}$

Figure 2 — Quadruple-timing method

4.4 Phase-locked-loop method

See figure 3.

The principle of operation of this method is shown in figure 3. The pulses from the meter are introduced to input 1 of the phase comparator and the output signal is passed to the voltage controlled oscillator (VCO). This device generates pulses with a higher frequency proportional to its input voltage. This frequency is chosen to be higher than the meter frequency.

The output signal of the VCO is also fed back, through a frequency divider, to input 2 of the phase comparator. The frequency of the multiplied pulses is reduced by the divisor, *R*. The output voltage of the phase comparator is proportional to the difference in phase or frequency between its two inputs, so that the output frequency of the VCO is continually being servo-controlled to ensure that the frequency and phase of the two inputs are identical. The selection of frequency divisor, *R*, thus determines the pulse interpolation divisor.

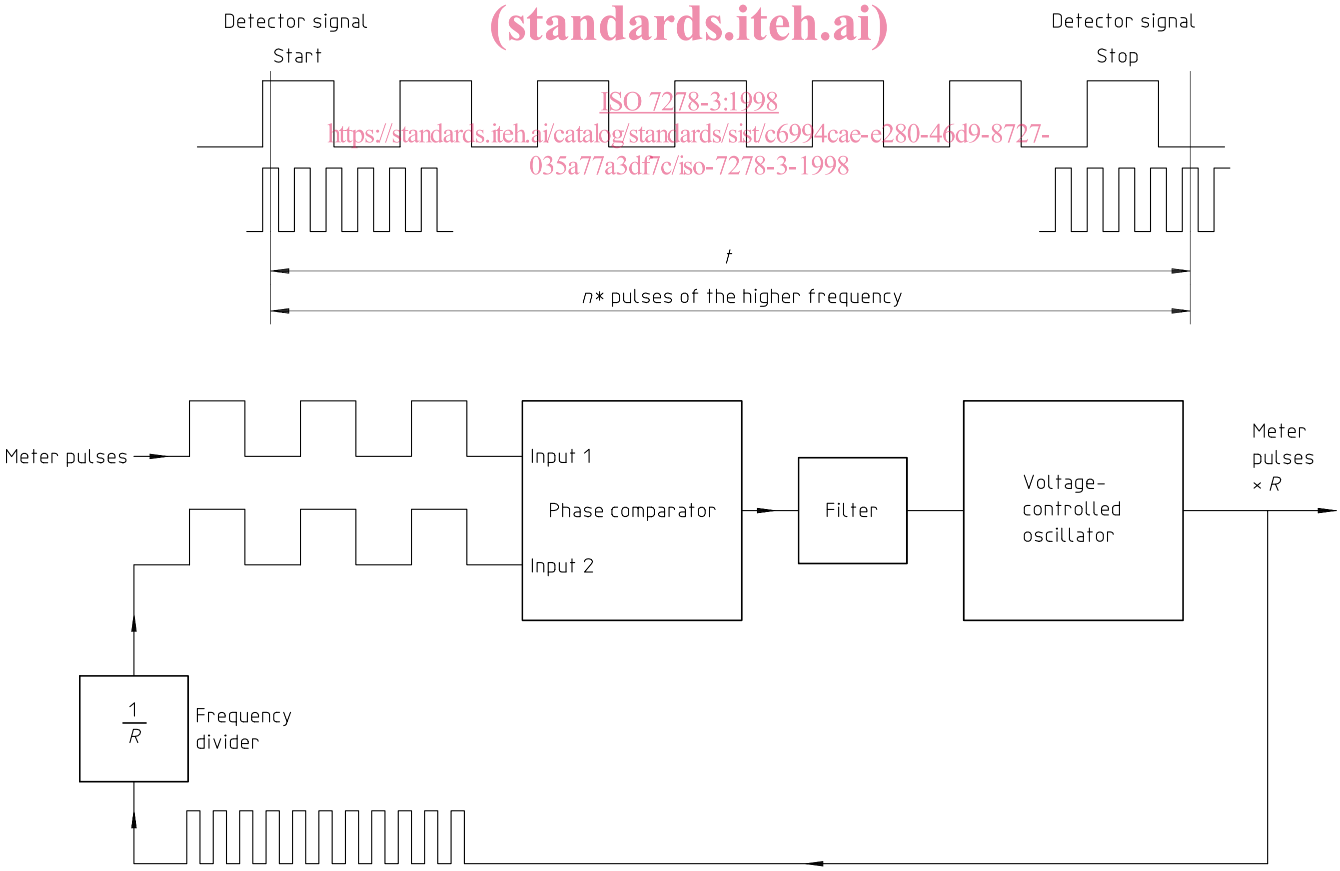
The interpolated number of pulses collected during the proving run is normally expressed as

$$n' = \frac{n^*}{R}$$

where

n^* is the number of multiplied pulses collected from the multiphase output;

R is the selected divisor (or multiplication factor).



Interpolated number of pulses, $n' = \frac{n^*}{R}$

Figure 3 — Phase-locked-loop method

To achieve precise control, it is necessary to filter the output of the phase comparator to avoid sudden VCO changes. This filter, normally of the simple RC type, has the property of momentarily retaining the voltage required by the VCO to keep generating *R* times the meter frequency between each phase comparison. Selection of the filter's time constant should be chosen to provide stability but not mask changes in input pulse frequency due to flowrate fluctuation.

5 Conditions of use

5.1 General

The following conditions shall apply generally to all the pulse interpolation methods described in this part of ISO 7278.

a) Resolution

The resolution of the indication device attached to the system shall in all instances be better than 1 in 10 000.

b) Number of significant digits for n'

As stated in 4.1 b), the number n' will not necessarily be a whole number. For the timing methods which yield a fractional result, there will be a practical limit on the number of decimal places which are used for n'. In practice the improvement by pulse interpolation is not unlimited, as n' shall be rounded to five significant digits, not more and not less.

c) Stability of flowrate

The pulse interpolation methods are based on the assumption that the flow is stable during the period of the proving. To maintain the stability of the flow, the fluctuations in the flowrate during a pass of the prover displacer, shall be less than ± 2 % of the mean flowrate.

NOTES

1 The pulse interpolation equipment is tested under conditions of simulated flowrate variation (see 7.3) to show satisfactory operation with such fluctuations.

2 The stability of the meter frequency will be the parameter normally used to assess flow stability.

d) Immunity from electrical interference

The equipment used shall be immune from electrical interference (see 7.4). In particular, the signal-to-noise ratio shall be adequately high.

e) Detector switch signal

The switching edge from the detector shall be well-defined and repeatable (some mechanical switches produce signals with non-repeatable lagging edges due to switch bounce). It is, however, necessary to use the same edge in each case.

f) Clock stability

Any clock used for timing shall have a stability commensurate with the required resolution.

5.2 Double-timing method

5.2.1 Resolution

To obtain a resolution better than ± 0,01 %, the period of the test, i.e. the time T_2 (see figure 1), shall be at least 20 000 times greater than the reference period t_c of the clock (i.e. the reciprocal of the clock frequency) used to measure the time-intervals.