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Hydraulic fluid power — Determination of fluid-borne noise characteristics of components and systems —

Part 1: Introduction

Transmissions hydrauliques — Évaluation des caractéristiques du bruit liquidien des composants et systèmes —

Partie 1: Introduction

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this part of ISO 15086 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15086-1 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 8, *Product testing*.

ISO 15086 consists of the following parts, under the general title *Hydraulic fluid power — Determination of fluid-borne noise characteristics of components and systems*:

— *Part 1: Introduction*

— *Part 2: Measurement of the speed of sound in a fluid in a pipe*

Introduction

The airborne noise emitted by hydraulically actuated equipment is the result of simultaneous acoustic radiation from all mechanical structures comprising the machine. The contribution from individual components generally forms only a small part of the total acoustic energy radiated. Acoustic intensity measurement techniques have demonstrated that the pulsating energy in the hydraulic fluid (fluid-borne noise) is the dominant contributor to machine noise. In order to develop quieter hydraulic machines it is therefore necessary to reduce this hydro-acoustic energy.

Various approaches have been developed to describe the generation and transmission of fluid-borne noise in hydraulic systems. Of these, the transfer matrix approach has the merit of providing a good description of the physical behaviour as well as providing an appropriate basis for the measurement of component characteristics.

Hydraulic fluid power — Determination of fluid-borne noise characteristics of components and systems —

Part 1: **Introduction**

1 Scope

This part of ISO 15086 provides a general introduction to transfer matrix theory, which allows the determination of the fluid-borne noise characteristics of components and systems. It also provides guidance on practical aspects of fluid-borne noise characterization.

This part of ISO 15086 is applicable to all types of hydraulic fluid power circuits operating under steady-state conditions for fluid-borne noise over an appropriate range of frequencies.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 15086. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 15086 are encouraged to investigate the possibility of applying the most recent editions of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 5598, *Fluid power systems and components — Vocabulary*

3 Terms and definitions

For the purposes of this part of ISO 15086, the terms and definitions given in ISO 5598 and the following apply.

3.1
flow ripple
fluctuating component of flow rate in a hydraulic fluid, caused by interaction with a flow ripple source within the system

3.2
pressure ripple
fluctuating component of pressure in a hydraulic fluid, caused by interaction with a flow ripple source within the system

3.3
hydraulic noise generator
hydraulic component generating flow ripple and consequently pressure ripple in a circuit, or hydraulic component generating pressure ripple and consequently flow ripple in the circuit

3.4
fundamental frequency
lowest frequency of pressure (or flow) ripple considered in a theoretical analysis or measured by the frequency-analysis instrument

EXAMPLE 1 A hydraulic pump or motor with a shaft frequency of N revolutions per second may be taken to have a fundamental frequency of N Hz. Alternatively, for a pump or motor with k displacement elements, the fundamental frequency may be taken to be Nk Hz, provided that the measured behaviour does not deviate significantly from cycle to cycle.

EXAMPLE 2 A digital frequency analyzer has a fundamental frequency defined by the frequency of the first spectral line.

3.5
harmonic
sinusoidal component of the pressure ripple or flow ripple occurring at an integer multiple of the fundamental frequency.

NOTE A harmonic may be represented by its amplitude and phase or alternatively by its real or imaginary parts.

3.6
impedance
complex ratio of the pressure ripple to the flow ripple occurring at a given point in a hydraulic system and at a given frequency

NOTE Impedance may be expressed in terms of its amplitude and phase or alternatively by its real and imaginary parts.

3.7
admittance
reciprocal of impedance

3.8
characteristic impedance of a pipeline
impedance of an infinitely long pipeline of constant cross-sectional area

3.9
wavelength
ratio of the speed of sound to the frequency of interest (in hertz)

3.10
anechoic
without reflection

NOTE With reference to a condition in which a travelling wave is propagated but no energy is reflected back in the direction of propagation.

3.11
hydro-acoustic energy
fluctuating part of the energy in a liquid

3.12
broad-band fluid-borne noise
hydro-acoustic energy distributed over the frequency spectrum

3.13
port-to-port symmetry
property of a two-port component in which the wave propagation characteristics remain the same when its port connections to the circuit are reversed

4 Symbols

The following symbols are used in this part of ISO 15086.

A, A', A^*	Complex coefficient
B, B', B^*	Complex coefficient
C'	Complex coefficient
c	Acoustic velocity
d	Internal diameter of pipe
f	Frequency (hertz)
f_0	Fundamental frequency (hertz)
j	Complex operator
L	Distance along pipe
n	Total number of harmonics
P	Fourier transform of pressure ripple
$p(t)$	Time-dependent pressure ripple
p_i	Amplitude of i-th harmonic of pressure ripple
Q	Fourier transform of flow ripple
$q(t)$	Time-dependent flow ripple
q_i	Amplitude of i-th harmonic of flow ripple
R	Magnitude of harmonic component (pressure or flow ripple, as appropriate)
t	Time
ε_{f}	Error in calculation of flow ripple at junction
φ_i	Phase of i-th harmonic of pressure ripple
ν	Kinematic viscosity
θ	Phase of harmonic component (pressure or flow ripple, as appropriate)
ω	Frequency (rads per second)
ψ_i	Phase of i-th harmonic of flow ripple

5 Basic considerations

5.1 General

The time-dependent pressure and flow ripples in a hydraulic system can be described mathematically by a Fourier series. Figure 1 shows, as an example, a periodic flow ripple signal in the time domain, while Figure 2 shows the corresponding frequency domain representation. The phase can lie in the range –180° to 180°.

The spectra shown in Figure 2 present the harmonic components in terms of their amplitude and phase. It is also possible to present these components in terms of their real and imaginary parts. Frequency domain representations are readily obtained using frequency analysis instrumentation.

For the determination of the fluid-borne noise characteristics of hydraulic components and systems, only periodic signals are considered.