YAMATAKE

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How to Predict Control Valve Noise [Prediction Calculation Formulas for Noise Levels of Control Valves, and Reference Data]

Instrumentation Data

Yamatake Corporation

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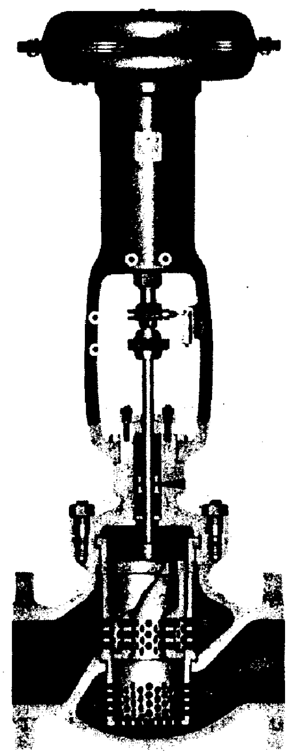
TABLE OF CONTENTS

I. PREDICTION OF CONTROL VALVE NOISE (SOUND PRESSURE LEVEL) FOR COMPRESSIBLE FLUIDS

1. Formula for Prediction of Control Valve Noise for Compressible Fluids

The level of noise generated by a control valve to be used to control a compressible fluid can be well predicted by employing a formula mentioned later, as measured at a point of 1 meter downstream from the valve outlet and 1 meter from the process pipe, and taking into calculation such terms as type of the fluid and dimensions of the process pipe.



(1) Terms to be Taken into Calculation When Predicting Noise Level

(a) Type of valve (HCN, HCB, etc.)

(b) Port diameter x Valve diameter (rated Cv value)

(c) Type of fluid

(d) Flow rate (See the Note.)

(e) Valve inlet and outlet pressures (See the Note.)

(f) Differential pressure of valve (See the Note.)

(g) Fluid temperature

(h) Specific-gravity or superheating

(i) Downstream pipe diameter and schedule number (wall thickness)

Note: When there are two or more operating conditions (such as normal flow and maximum flow), noise level may be calculated for each of them.

(2) Formula for noise Level Prediction

where, SPL: Predicted overall noise level of control valve (dB•A - Horn)

$SPL_{\Delta P}$: Base level (Noise of control valve depends primarily on the differential pressure between its inlet and outlet.) The level is corrected by the various factors as mentioned below. (See Figure 1.)

SPL_{CV} : Correction for Cv. Noise increases as flow increases. (See Figure 2.)

SPL_{V} : Correction for type of valve. With data acquired for different types (configurations) of valves. [HCB,HCN,VDC,VDN (for ANSI 600 or less, see Figure 3; for ANSI 900 - ANSI 2500, see Figure 4.)]

$SPL_{(t^2/D)}$: Correction for attenuation by pipe. Noise attenuated depending on downstream pipe diameter and schedule (wall thickness). (See Figure 5 and Table 1.)

(3) Calculation Method

(a) Determine the type of the valve.

(b) Calculate the Cv value from the conditions of flow and determine the valve size .... (1)
(Rated Cv is determined.)

(c) Calculate the Cv value from the conditions of flow when in running operation .... (2)

(d) From (1) and (2), calculate Cv% as follows:

$$L = \frac{\text{Calculated Cv}}{\text{Rated Cv}} \times 100$$

(e) Calculate pressure ratio $\Delta P/P_1$, where ΔP is the differential pressure (kgf/cm^2) across the valve and P_1 is the pressure (kgf/cm^2 abs) of the upstream side.

(f) Find $SPL_{\Delta P}$ ..... ΔP, from Figure 1

Find SPL_{CV} ..... Cv, from Figure 2

Find SPL_V ...... $\Delta P/P_1$, L, from Figure 3 or 4

Find $SPL_{(t^2/D)}$ ..... Pipe size, schedule number; from Figure 5 or Table 1

(g) Add the values found in (F).

2. Noise Level Prediction Calculation Examples

(1) Example 1

[Conditions of Flow]

Type of Fluid: Air

Fluid Pressures

Upstream Pressure: $P_1 = 16\ kgf/cm^2$ abs.

Downstream Pressure: $P_2 = 8\ kgf/cm^2$ abs.

Differential Pressure: $\Delta P = 8\ kgf/cm^2$

Calculated Cv: 200

[Conditions of Valve and Piping]

Type of Valve: HCN low-noise cage-type double-seat control valve

Valve Size: 6" x 6" (Cv = 330)

Downstream Pipe: 6", schedule 80

[Noise Level Prediction Calculation]

$SPL_{\Delta P} = 97$ dB ($\Delta P = 8\ kgf/cm^2 \rightarrow$ Fig. 1)

$SPL_{CV} = 2$ dB (Cv = 200 → Fig. 2)

$SPL_V = -5$ dB

$$L = \frac{200}{330} \times 100 \doteqdot 61$$

$$\Delta P/P_1 = 8/16 = 0.5$$

$SPL_{(t^2/D)} = -7$ dB (6" Sch. 80 → Table 1)

$\therefore SPL = 97 + 2 - 5 - 7 = 87$ dB·A

Assuming that a HCB cage-type double-seat control valve is used instead of the above, noise level is predicted as follows:

$SPL_V = +7$ dB ($\Delta P/P_1 = 0.5 \rightarrow$ Fig. 3)

$SPL = 97 + 2 + 7 - 7 = 99$ dB·A

(2) Example 2

[Conditions of Flow]

Type of Fluid: Air

Fluid Pressures

Upstream pressure: P_1 = 100 kgf/cm^2 abs.

Downstream pressure: P_2 = 55 kgf/cm^2 abs.

Differential pressure: ΔP = 45 kgf/cm^2

Calculated Cv: 220

[Conditions of Valve and Piping]

Type of Valve: VDN low-noise cage-type double-seat control valve (ANSI 1500)

Valve Size: 8" x 8" (Cv = 365)

Downstream Pipe: 8", Sch. 160

[Noise Level Prediction Calculation]

$SPL_{\Delta P}$ = 111 dB (ΔP = 45 kgf/cm^2 → Fig. 1)

SPL_{CV} = 2.5 dB (Cv = 220 → Fig. 2)

SPL_V = -7 dB

$$L = \frac{220}{365} \times 100 \fallingdotseq 60$$

$$\Delta P/P_1 = 45/100 = 0.45$$

$SPL_{(t^2/D)}$ = -17 dB (8" Sch. 160 → Table 1)

$\therefore$ SPL = 111 + 2.5 - 7 - 17 = 89.5 dB•A

Assuming that a HPC cage-type double-seat control valve (ANSI 1500) is used instead of the above, noise level is predicted as follows:

SPL_V = +6 dB ($\Delta P/P_1$ = 0.45 → Fig. 1)

$\therefore$ SPL = 111 + 2.5 + 6 - 17 = 102.5 dB•A

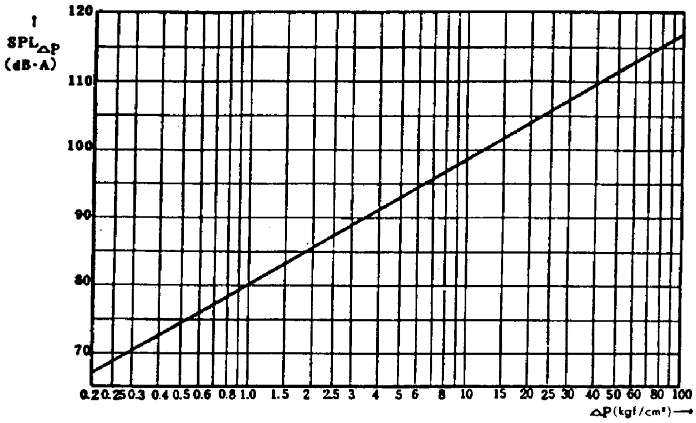


Figure 1. Base Level

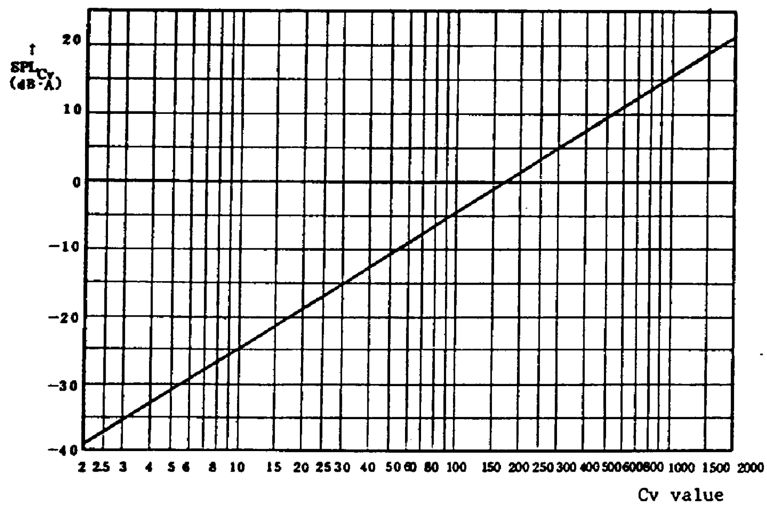


Figure 2. Correction for Flow Rate

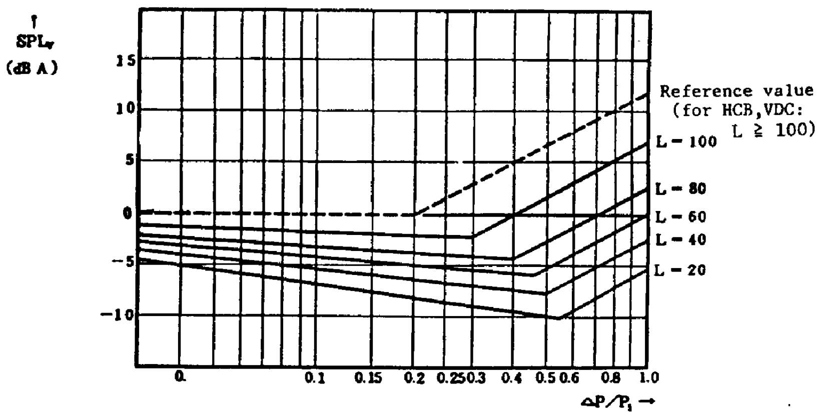


Figure 3. Correction for Type of Valve
(ANSI 600 or less)

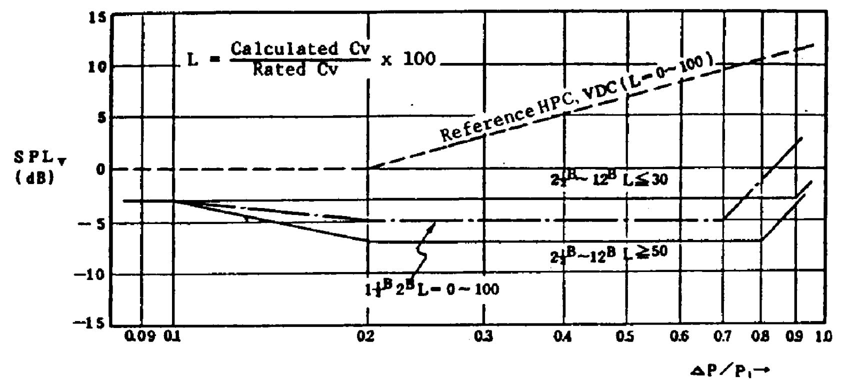


Figure 4. Correction for Type of Valve (ANSI 900 - 2500)

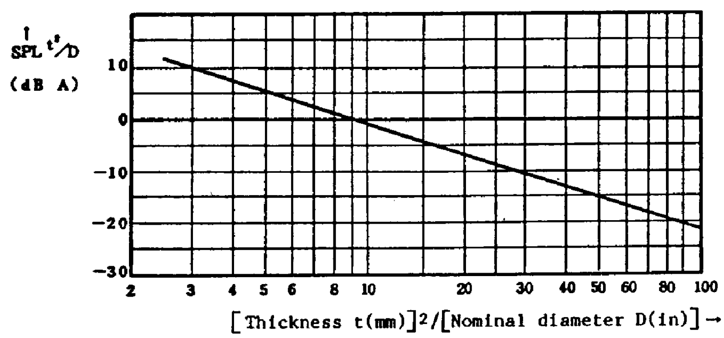


Figure 5. Correction for Downstream Pipe

Table 1. Correction for Downstream Pipe

Pipe size (Nominal diameter)	Schedule number										Standard gas pipe (S.G.P.)
	20	30	40	60	80	100	120	160	XS	XXS	
1 B (25A)			-2		-7			-13			-1
1½B (40A)			0		-5			-12	-5	-17	+1
2 B (50A)			+2		-4			-12	-4	-16	+2
2½B (65A)			-1		-6			-12	-6	-18	+2
3 B (80A)			-1		-6			-13	-6	-18	+4
4 B (100A)			0		-6		-10	-14	-6	-18	+5
5 B (125A)			+1		-6		-11	-15	-6	-18	+7
6 B (150A)			+1		-7		-11	-15	-7	-18	+7
8 B (200A)	+5	+3	+2	-3	-7	-8	-13	-17	-7	-16	+7
10B (250A)	+7	+3	+1	-5	-8	-11	-11	-19	-5		+7
12B (300A)	+9	+4	0	-7	-9	-15	-15	-20	-3		+7

II. PREDICTION OF CONTROL VALVE NOISE (SOUND PRESSURE LEVEL) FOR INCOMPRESSIBLE FLUIDS

1. Formula for Prediction of Control Valve Noise (Cavitation Noise) for Incompressible Fluids

The level of noise (cavitation noise) generated by a control valve to be used to control an incompressible fluid can be well predicted by employing a formula mentioned later, as measured at a point of 1 meter downstream from the valve outlet and 1 meter from the process pipe.

(1) Terms to be Taken into Calculation When Predicting Noise Level

(a) Type of valve

(b) Valve diameter (valve size)

(c) Type of fluid

(d) Flow rate (See the Note.)

(e) Valve inlet and outlet pressures (See the Note.)

(f) Differential pressure of valve (See the Note.)

(g) Specific gravity

(h) Inlet fluid temperature

(i) Superheated steam pressure at inlet fluid temperature

(j) Downstream pipe diameter and schedule number

Note: When there are two or more operating conditions (such as normal flow and maximum flow), noise level may be calculated for each of them.

(2) Formula for Noise Level Prediction

where, SPL: Predicted overall noise level of control valve (dB•A)

$SPL_{\Delta P}$: Noise which depends on differential pressure of valve (See Figure 6.)

SPL_{CV} : Noise which depends on Cv (See Figure 7.)

SPL_{P_1} : Noise which depends on upstream pressure (See Figure 8.)

SPL_{V} : Noise which depends on type of valve, flow control characteristics, and cavitation factor (See Figure 9 for HCB,HPC,VDC or Figure 10 for HLS,HTS,HPS,VST.)

SPL_{t} : Noise reduction by downstream pipe thickness (See Table 2.)

(3) Calculation Method

(a) Determine the type of the valve.

(b) Calculate the Cv value from the conditions of flow and determine the valve size. (Rated Cv for the valve size is determined.)

(c) Calculate the Cv value from the conditions of flow when in running operation.

(d) Calculate cavitation factor K as follows:

$$K = \Delta P/(P_1 - Pv)$$

(e) Find $SPL_{\Delta P}$ ..... Figure 6

Find SPL_{CV} ..... Figure 7

Find SPL_{P_1}..... Figure 8

Find SPL_V...... Figure 9 for HCB,HPC,VDC or Figure 10 for HLS,HTS,HPS,VST.

Find SPL_t...... Table 2

ΔP: Differential pressure (kgf/cm^2)

P_1: Upstream pressure (kgf/cm^2 abs.)

P_v: Saturated steam pressure (kgf/cm^2 abs.) at upstream temperature

(f) Add the values found in (e).

2. Noise Level Prediction Calculation Examples

[Conditions of Flow]

Type of Fluid: Water

Fluid Pressures

Upstream Pressure: $P_1 = 10$ kgf/cm^2 abs.

Downstream Pressure: $P_2 = 6$ kgf/cm^2 abs.

Differential Pressure: $\Delta P = 4$ kgf/cm^2

Fluid Temperature: 100 deg. C
(Saturated steam pressure: 1 kgf/cm^2 abs.)

Calculated Cv: 211

[Conditions of Valve and Piping]

Type of Valve: HCB cage-type double-seat control valve or HTS top-guided single-seat control valve

Valve Size: 6" x 6"

Control Characteristics: Equal percent type

Downstream Pipe: 6", Schedule No. 40

[Noise Level Prediction Calculation]

(a) For HCB

$SPL_{\Delta P} = 59$ dB ($\Delta P = 4$ kgf/cm^2 → Fig. 6)

$SPL_{Cv} = 23$ dB (Cv = 211 kgf/cm^2 → Fig. 7)

$SPL_{P_1} = -6$ dB ($P_1 = 10$ kgf/cm^2 abs. → Fig. 8)

$SPL_v = 3.5$ dB

$(\Delta P/(P_1 - P_v) = 4/(10-1) \doteqdot 0.45$ → Fig. 9)

$SPL_t = 0$ dB (6", Sch. 40 → Table 2)

$\therefore SPL = 59 + 23 - 6 + 3.5 + 0 = 79.5$ dB·A

(b) For HTS

$SPL_v = 7.5$ dB[$(\Delta P/P_1 - P_v) \fallingdotseq 0.45$ → Fig. 10]

$\therefore SPL = 59 + 23 + 6 + 7.5 + 0 = 83.5$ dB·A

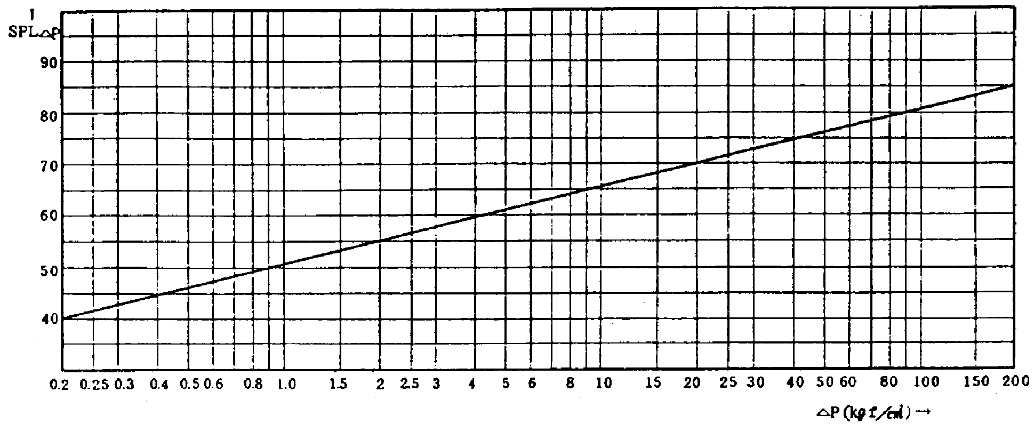


Figure 6. SPL△P v·s △P

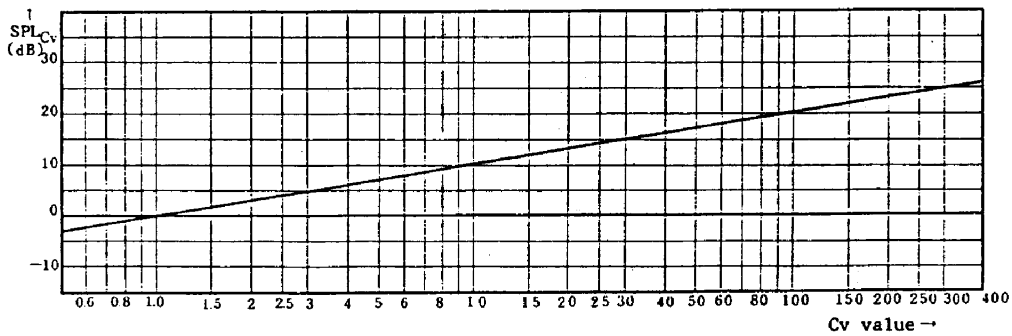


Figure 7. SPLcv v·s Cv

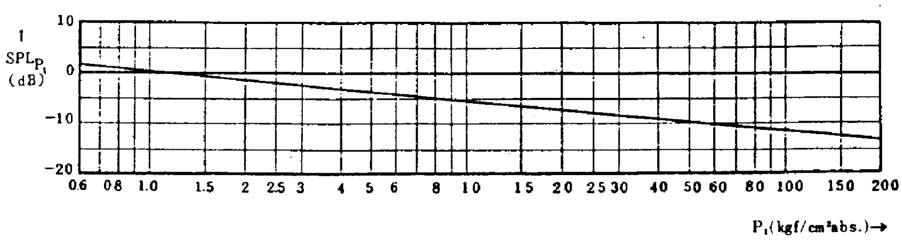


Figure 8. SPLP1 v·s P1

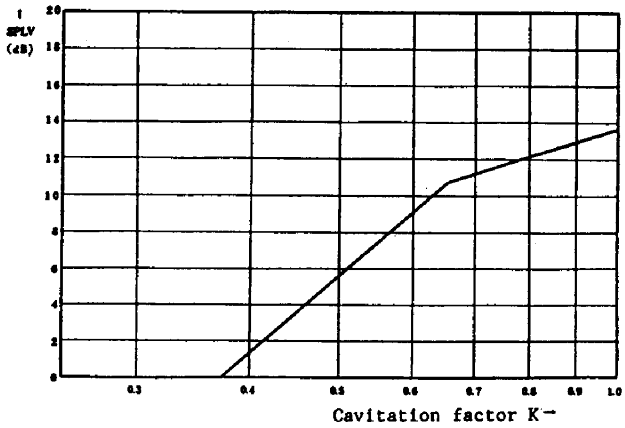


Figure 9. SPLv V·SK (for HCB,HPC,VDC)

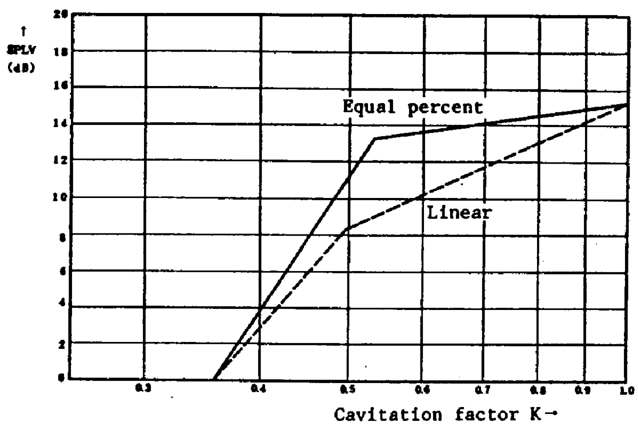


Figure 10. SPLv V·SK (for HLS,HTS,HPS,VST)

Table 2. Noise Attenuation by Downstream Pipe (dB)

Pipe size (in.)	Schedule number		
	SCH40	SCH80	SCH160
1	0	0	-2
1½	0	0	-2
2	0	0	-2
2½	0	0	-2
3	0	0	-2
4	0	-2.5	-5
6	0	-2.5	-5
8	0	-2.5	-5
10	0	-3	-7
12	0	-3	-7
14	0	-3	-7
16	0	-3	-7

III. REFERENCE MATERIALS

1. Examples of Actually Measured Control Valve Noise Data

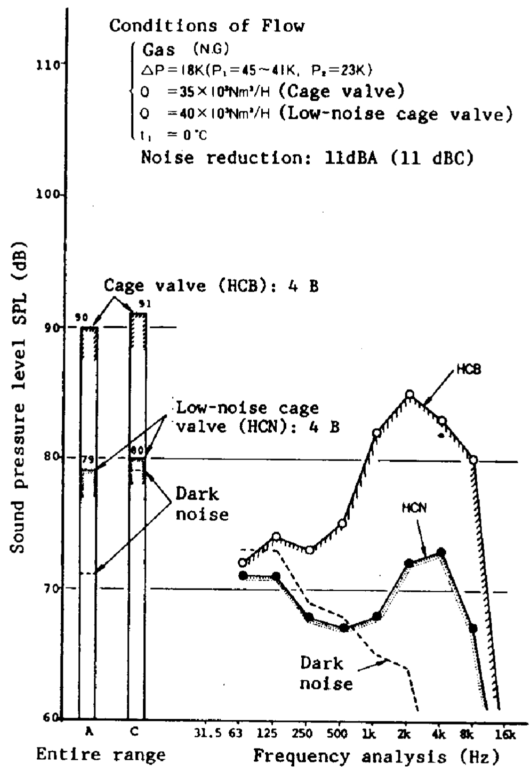


Figure 11. Noise Reduction by Low-noise Cage Valve for Gas Fluid

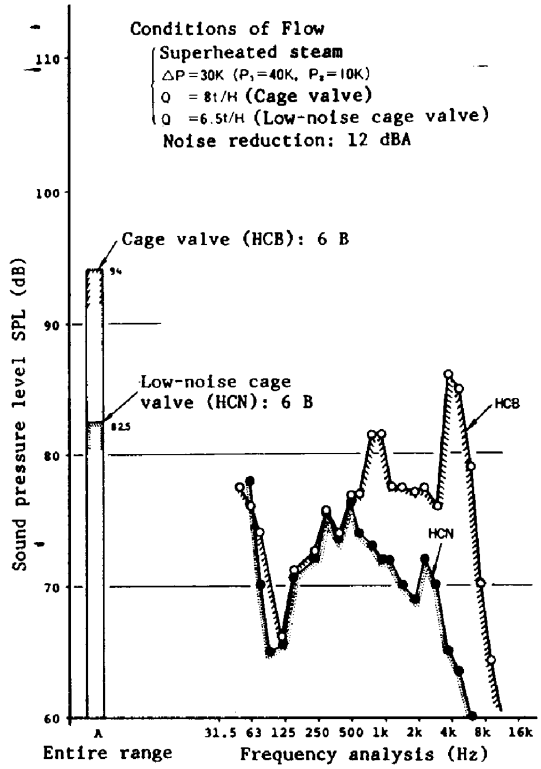


Figure 12. Noise Reduction by Low-noise Cage Valve for Stem Fluid

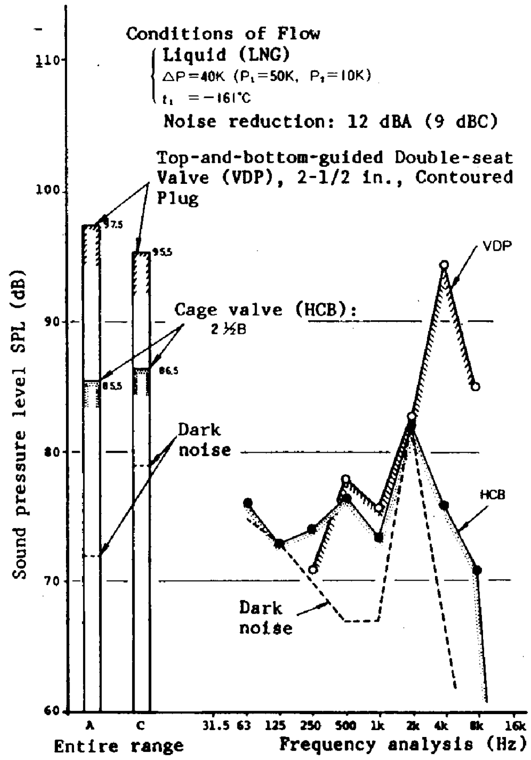


Figure 13. Reduction of Cavitation Noise of Cage Valve for Liquid Fluid

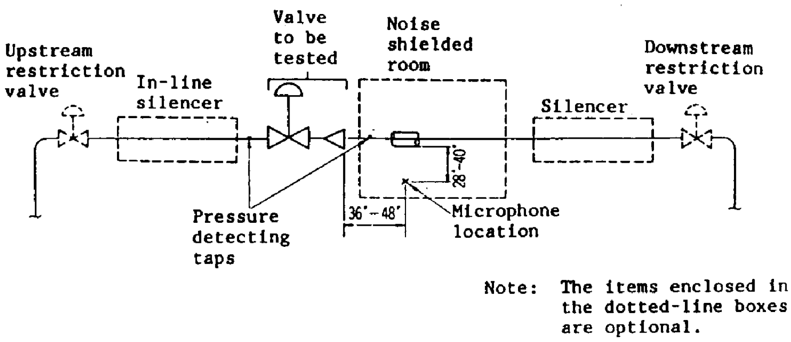


Figure 14. Laboratory Test Set-up for Control Valve Noise Measurement as per ISA RP 59.1

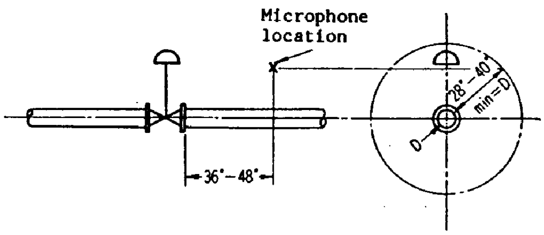


Figure 15. Actual Plant Test Set-up for Control Valve Noise Measurement as per ISA RP 59.2

2. Control Valve Noise Measuring Method

Since the noise level depends on the distance form the source of noise and the measuring point (location of the microphone), evaluations of noise characteristics of control valves become meaningless unless the locations of the microphones with respect to the tested control valves are standardized and uniform. The ISA recommends microphone location as shown in Figures 14 and 15, with distances as follows:

(a) From valve outlet in downstream direction: 36 - 48 inches (0.9 - 1.2 m)

(b) From pipe outer surface: 28 - 40 inches (0.7 - 1.0 m)

The ISA recommends the items to be recorded when measuring, as shown in Table 3.

Table 3. Items to be Recorded When Measuring Control Valve Noise

Item	In laboratory	At actual plant
Type of Objective Valve	○	○
Valve Upstream Pressure	○	○
Valve Differential Pressure or Downstream Pressure	○	○
Valve Upstream Fluid Temperature	○	○
Flow Rate	○(Accuracy: ± 5%)	○ (Note 1)
Molecular Weight or Specific-gravity of Liquid	○	○
Valve Position (Opening)	○(Accuracy: ± 1%)	○ (Note 1)
Pipe Size and Schedule	○	○ (Both upstream and downstream sides)
Piping Layout	○	○ (Including a sketch)
Noise Level (SPL) (Note 2)	○	○
Correction for Ambient Noise	○(Performance of noise shield room, etc.)	○ (Note 3)
Calibration and Correction Data of Measuring Instruments	○	○
Location of Microphone	○	○ (Note 4)

Note 1: Accuracy for actual plant is not indicated.

Note 2: Should be measured with dB•A scale at least. At actual plant, measurement should be made when wind velocity is 10 knots (5 in./sec.) or more.

Note 3: For correction for ambient noise, refer to ANSI S1.2 Para. 2.5.1 "Correction Ambient Sound Pressure Level."

Note 4: When the maximum noise SPL_{max} is measured at a location other than the specified location, record the SPL_{max} value and the measured location.

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