Catalog 12
Section 3 tab

The current hydrodynamic noise prediction method differentiates valve style only though variation of the pressure recovery coefficient, Km (F_L^2). Separate noise prediction corrections have now been established for standard valves, Cavitrol III - 1 Stage valves, and the rotary attenuator. These differences are reflected in the ΔSPL_{Ar} term of the general sound pressure level prediction equation per the following equation:

$$\Delta SPL_{Ar} = a - b\left(\frac{K_m}{Ar}\right) + 10\log\left(\frac{1}{Ar} - 1\right)$$

where,

ΔSPL_{Ar} = Correction for effects of Ar and valve style

K_m = Pressure recovery coefficient

Ar = Application ratio

$$= \frac{\Delta P_{Actual}}{P_1 - P_v}$$

a, b = coefficients given in following table:

	a	b
Standard Valves	14.4	18.8
Cavitrol III - 1 stage	9.4	18.8
Rotary Attenuator	9.4	22.6

Line Source

Equal Noise levels are on an imaginary cylinder with the pipe centerline as the axis (figure 1). As an observer moves away from the pipeline, the sound pressure level (SPL) decreases inversely to the changes in surface area of the imaginary cylinder. Use the following equation to find the sound pressure level when other than 1 meter from the pipeline surface.

$$SPL = F + 10 Log \frac{1 + r}{R + r}$$

where,
r = radius of pipe based on outside diameter (meters)
R = distance from pipe surface (meters)
F = noise level calculated at 1 meter

Example

What is the noise level 50 feet from a 12 inch pipeline (from table 1, radius is 6.38 inch or 0.16 m) when the Noise Prediction Technique calculates 95 dBA at 1 meter.

$$SPL = (95) + 10 Log \frac{1 + 0.16}{15.24 + 0.16}$$
$$SPL = 95 - 11.2$$
$$SPL = 83.8 \text{ dBA}$$

Note

This procedure determines the noise level radiated only by the pipeline. Other noise sources could combine with the pipeline noise source to have a greater overall sound pressure level.

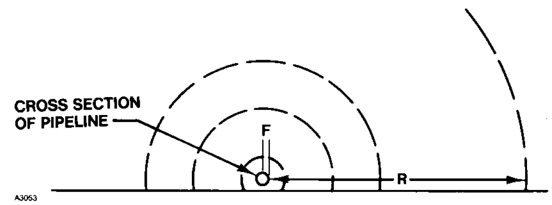

Figure 1. Typical Line Source

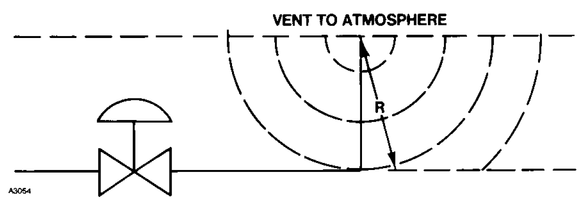

Figure 2. Typical Point Source

Point Source

Vent applications are typical examples of point source noise (figure 2). As an observer moves away from a point source, the sound level (SPL) decreases inversely to the changes in surface area of the imaginary sphere. Use the following equation to find the sound pressure level when other than 3 meters from the point source and below a horizontal plane through the point source.

$$SPL = F + 20 Log \frac{3}{R}$$

where,
R = distance from source (meters)
F = noise level calculated at 3 meters

Example

What is the noise level 50 feet (15 meters) from the point source when the Noise Prediction Technique calculates 100 dBA at 3 meters.

$$SPL = 100 + 20 Log \frac{3}{15}$$
$$SPL = 100 - 14$$
$$SPL = 86 \text{ dBA}$$

Note

This procedure determines the noise level radiated only by the point source. Other noise sources could combine with the point source noise to have a greater overall sound pressure level.

Table 1. Radii of Nominal Pipe Sizes

RADIUS OF PIPE	NOMINAL PIPE SIZES, INCHES																
	1/2	3/4	1	1-1/2	2	2-1/2	3	4	6	8	10	12	16	20	24	30	36
Inch	0.42	0.53	0.66	0.95	1.19	1.44	1.75	2.25	3.31	4.31	5.38	6.38	8.00	9.00	12.00	15.00	18.00
Meter	0.0107	0.0133	0.0168	0.0241	0.0302	0.0366	0.0445	0.0572	0.0841	0.11	0.14	0.16	0.20	0.23	0.30	0.38	0.46

Octave Band Sound Pressure Levels

Aerodynamic noise has an overall sound pressure level (measured one meter downstream of the valve and one meter away from the pipe-wall) which does not indicate the sound pressure level in each frequency band. Use the information in table 1 to determine octave band sound pressure levels and to construct a spectrum for a particular trim type and piping combination.

Example

A 6-inch valve with Whisper Trim® III cage has an overall SPL of 85 dBA. The octave band SPLs are as follows:

SPL at 63 Hz = 85 + (−50) = 35 dBA
125 Hz = 85 + (−50) = 35 dBA
250 Hz = 85 + (−45) = 40 dBA
500 hZ = 85 + (−33) = 52 dBA
1000 Hz = 85 + (−21) = 64 dBA
2000 Hz = 85 + (−9) = 76 dBA
4000 Hz = 85 + (−6) = 79 dBA
8000 Hz = 85 + (−3) = 82 dBA

Table 1. Octave Band Sound Pressure Level Corrections

PIPE SIZE INCH	PIPE SCHEDULE	FOR WHISPER TRIM® III (OUTLET VELOCITY $\leq$ 0.3 MACH)								FOR ALL OTHERS							
		Octave Bands, Hz															
		63	125	250	500	1000	2000	4000	8000	63	125	250	500	1000	2000	4000	8000
1	5S to XXS	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−50	−50	−50	−39	−27	−15	−6	−3
1-1/2	5S to XXS	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−50	−50	−50	−39	−27	−15	−6	−3
2	5S to XXS	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−50	−50	−50	−39	−27	−15	−3	−6
3	5S to XXS	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−50	−50	−50	−39	−27	−15	−3	−6
4	5S to XXS	- - -	- - -	- - -	−45	−33	−21	−9	−6	−50	−50	−50	−39	−27	−15	−3	−6
6	5S to XXS	−50	−50	−45	−33	−21	−9	−6	−3	−50	−50	−39	−27	−15	−3	−6	−9
8	5S to 160	−50	−50	−45	−33	−21	−9	−6	−3	−50	−50	−29	−27	−15	−3	−6	−9
10	5S to 160	−50	−50	−45	−33	−21	−9	−6	−3	−50	−50	−39	−27	−15	−3	−6	−9
12	5S to 160	−50	−45	−33	−21	−9	−6	−3	−9	−50	−39	−27	−15	−3	−6	−9	−21
14	5S to 160	−50	−45	−33	−21	−9	−6	−3	−9	−50	−39	−27	−15	−3	−6	−9	−21
16	5S to 160	−50	−45	−33	−21	−9	−6	−3	−9	−50	−39	−27	−15	−3	−6	−9	−21
18	5S to 160	−50	−45	−33	−21	−9	−6	−3	−9	−50	−39	−27	−15	−3	−6	−9	−21
20	5S to 160	−50	−45	−33	−21	−9	−6	−3	−9	−50	−39	−27	−15	−3	−6	−9	−21
24	5S to 160	−45	−33	−21	−9	−6	−3	−9	−15	−39	−27	−15	−3	−6	−9	−21	−33
	120 to 160	−50	−45	−33	−21	−9	−6	−3	−9	−50	−39	−27	−15	−3	−6	−9	−21
30	5S to 30	−45	−33	−21	−9	−6	−3	−9	−15	−39	−27	−15	−3	−6	−9	−21	−33
36	10 to 40	−45	−33	−21	−9	−6	−3	−9	−15	−39	−27	−15	−3	−6	−9	−21	−33
42	10 to 30	−45	−33	−21	−9	−6	−3	−9	−15	−39	−27	−15	−3	−6	−9	−21	−33

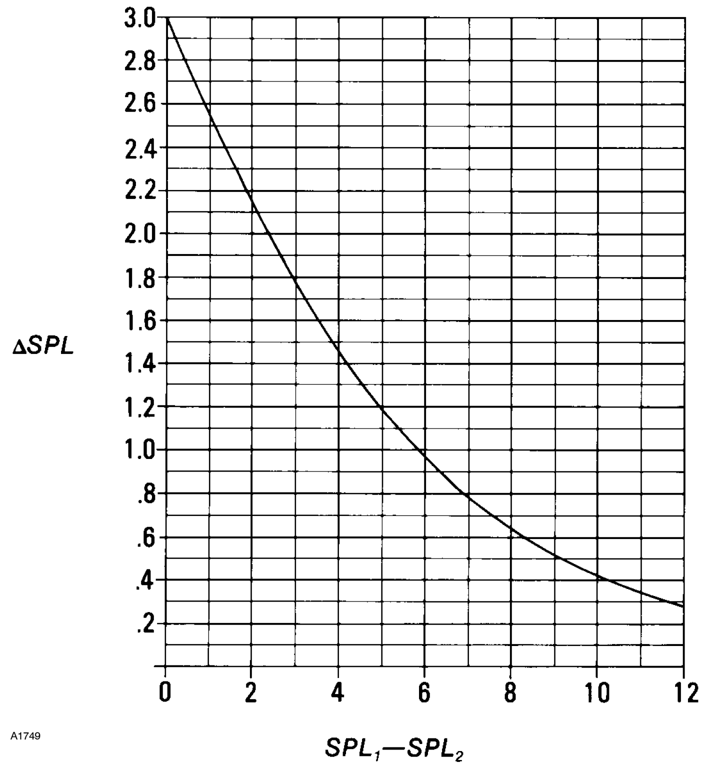

Figure 1. Noise Source Combination Curve

Combining Noise Sources

Two noise levels, calculated separately, can be combined as one overall noise source. The sources can be point, line or a combination of both. Use the following technique.

1. Calculate the noise level of each source at the point where the combined noise level is desired. Use either the line source or point source techniques found on page 3-2.

2. Find the difference in the sound pressure level of the two sources at the new location.

3. Enter the abscissa of figure 1 with the difference found in step 2. Move vertically to intersect the curve. Read ΔSPL at this point.

4. The overall noise level of the two sources is the loudest noise source plus the ΔSPL found in step 3.

Introduction

The major cause of hydrodynamic noise (noise resulting from liquid flow) is cavitation. Cavitation is the process of the formation and subsequent collapse of vapor bubbles in a flowing liquid stream. The noise and damage produced by cavitation may be traced to the collapse of these vapor bubbles. When the vapor bubbles do not collapse, flashing occurs, potentially causing trim damage but little hydrodynamic noise.

Source Treatment

Cavitation and its associated noise and damage can often be avoided at the design phase of a project if proper consideration is given to service conditions. However, where service conditions are fixed, a valve may have to operate at pressure conditions normally resulting in cavitation. In such instances, noise control by source treatment can be employed by utilizing one of several methods: multiple valves in series, a special control valve, or a standard control valve body with special internal parts.

Cavitrol® III one-stage trim utilizes specially-shaped, diametrically-opposed holes through the cage wall that reduce the fluid's tendency to cavitate and reduce fluid turbulence. When the application pressure drop is within stated values, the trim helps eliminate the cavitation noise and damage.

Cavitrol III two- and three-stage and Cavitrol IV trims eliminate cavitation noise and damage by taking the total pressure drop in a series of intermediate stages. In operation, fluid enters the first section of the cage through many orifices. In passing through orifices, each fluid stream undergoes a portion of the total pressure drop. The fluid then passes through a series of additional orifices and undergoes additional pressure drops at each stage. The number of stages required to prevent cavitation damage depends upon the total amount of pressure reduction that must be taken across the cage. A control valve using two- or three-stage Cavitrol III or Cavitrol IV trim will exhibit a sound pressure level of 90 dBA or less.

Cavitrol V trim, for use with Vee-Ball® valves, minimizes cavitation noise and damage by controlling the formation and collapse of vapor bubbles. The trim consists of a carefully designed bundle of tubes installed within the valve, downstream of the V-notch ball. The tubes prevent the flow stream from reaching its potential minimum area, thus maintaining maximum pressure head and reducing the possibility of vapor bubble formation. Also, the tubes physically limit the size and number of vapor bubbles that can form. In many installations, Cavitrol V trim creates resistance to the flow stream, which produces a back pressure. This back pressure can keep the pressure head from falling below the vapor pressure of the process liquid. Cavitrol V trim can reduce control valve noise by as much as 15 dBA.

Table 1 lists available Cavitrol trims.

Table 1. Available Cavitrol® Trim

Trim	Body Rating Class	Body Design
Cavitrol III One-Stage	125 to 600	ET
	150 to 900	EWT ELT
	900 through 2500	DBAQ
	Note 1	CC
Cavitrol III Two-Stage	600	ET EWT
	900	EWT (8 x 6 & 12 x 8 inch) ELT DBAQ EHT
	1500	DBAQ EHT
	2500	DBAQ EHT
Cavitrol III Three-Stage	900 through 2500	DBAQ EHT
Cavitrol IV	2500	CAV 4
Cavitrol V	150 and 300 150 through 600	U V100

Note 1: 10,000 psig API (American Petroleum Institute).

Path Treatment

Path treatment of cavitation noise is not generally recommended since cavitation is usually accompanied by severe physical damage to the valve parts or piping components. Such cavitation should not go unchecked because of the potential hazard of eventual valve and piping failure. However, Cavitrol III one-stage trim in a properly-sized valve can be used to control cavitation damage, thus allowing use of the path treatment approach to reduce noise.

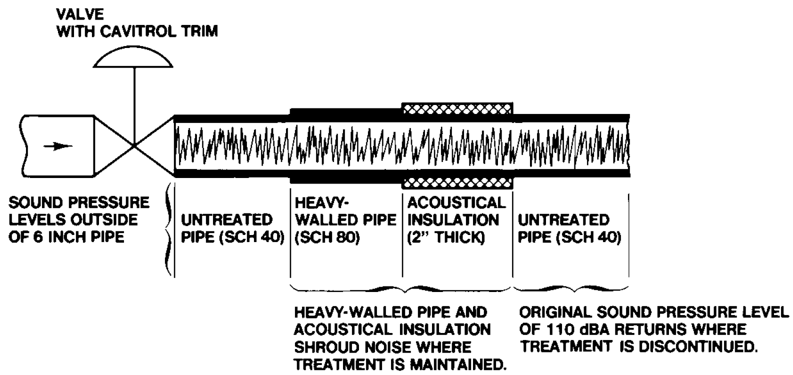

Figure 1. Typical Path Treatments

To help control cavitation damage, Cavitrol III one-stage trim utilizes a number of pairs of small, diametrically-opposed flow holes through the wall of the cage. Each specially shaped hole admits a jet of cavitating liquid which impacts at the center of the cage with the jet admitted from the opposing hole. Thus a continuous cushion is formed which prevents cavitating liquid from contacting the metal surfaces, ensuring the vapor bubble collapse takes place in the center of the flow stream.

Once the cavitation damage is controlled in this manner, it becomes practical to use the path treatment method (figure 1) to reduce the local noise caused by the cavitating liquid. This may be accomplished through the use of heavy-walled pipe and acoustical or thermal insulation.

Pipe wall attenuation varies with size and schedule. See page 3-9.

Thermal insulation will give approximately three to five dBA attenuation per inch of insulation thickness. Twelve to fifteen dBA is the maximum attenuation that should be expected even with several inches of insulation. Please consult manufacturer's specifications for attenuating capability and application of specific insulation (including higher pipeline temperatures and lower allowable stresses).

Acoustical insulation will give an approximate eight to ten dBA attenuation per inch of blanket type insulation; twenty-four to twenty-seven dBA is the maximum attenuation that should be expected even with several inches of insulation. Please consult manufacturer's specifications for attenuating capability and application of specific insulation.

Introduction

Use the following procedure to determine the A-weighted sound pressure level (SPL) noise generated by liquid flow through control valves. The information needed is:

- Valve style and type of trim
- Size and schedule of adjacent piping
- Inlet pressure (P_1, psia) and pressure drop (ΔP,psi)
- Vapor pressure of the liquid (P_v, psia)
- Calculated required C_v
- Recovery coefficient (K_m)
- Specific gravity if different from water

Hydrodynamic noise in a control valve is dependent on the nature of the pressure recovery downstream of the valve orifice. If the recovery is such that cavitation is present, the resultant noise is higher than if the fluid did not cavitate.

The transition from non-cavitating to cavitating is included in the prediction technique. Therefore, the user does not have to determine the onset of cavitation. This level of cavitation is not the same as the levels of cavitation determined by K_m and K_c.

To calculate the predicted hydrodynamic noise, solve both the non-cavitating and cavitating equations and use the greater of the two as the noise prediction.
This procedure can be used for all designs except Cavitrol® III two- and three-stage trims and Cavitrol IV trim. With Cavitrol III two- and three-stage trims and with Cavitrol IV trims, the sound pressure level will never exceed 90 dBA. For these trims, an additional upper limit of 90 dBA is placed on this procedure because these trims prevent cavitation.

Prediction Technique

Non-Cavitating

$$SPL = SPL_{\Delta P} + \Delta SPL_{Cv} + \Delta SPL_{k} + \Delta SPL_{km} + \Delta SPL_{g}$$

Where

SPL	=	Overall noise level (dBA) in decibels at a predetermined point (1 meter downstream of the valve outlet and 1 meter from the pipe surface)
$SPL_{\Delta P}$	=	Base SPL in dB, determined as a function of pressure drop (ΔP)
ΔSPL_{Cv}	=	Correction in dB for required liquid sizing coefficient (C_v)
ΔSPL_K	=	Correction in dB achieved through the use of heavy-walled pipe and acoustical or thermal insulation
ΔSPL_{Km}	=	Correction in dB for given recovery coefficient (K_m)
ΔSPL_G	=	Correction in dB for fluids with a specific gravity value which differs from the water (for water, $\Delta SPL_G = 0$)

Cavitating

$$SPL = SPL_{\Delta p} + \Delta SPL_{Cv} + \Delta SPL_K + \Delta SPL_{AR}$$

Where

SPL	=	Overall noise level in decibels (dBA) at a predetermined point (1 meter downstream of the valve outlet and 1 meter from the pipe surface)
$SPL_{\Delta P}$	=	Base SPL in dB determined as a function of pressure drop (ΔP)
ΔSPL_{Cv}	=	Correction in dB for required liquid sizing coefficient (C_v)
ΔSPL_k	=	Correction in dB achieved through the use of heavy-walled pipe and acoustical of thermal insulation
ΔSPL_{AR}	=	Correction in dB for applications ratio [AR $= \Delta P/(P_1 - P_v)$] and the recovery coefficient (K_m)

Prediction Example

Given:

Valve style—Design ED
Type of trim—standard
Adjacent piping—4-inch schedule 40 pipe
Recovery coefficient (K_m)—.7

Inlet pressure (P_1)—250 psia
Pressure drop (ΔP)—175 psi
Vapor pressure(P_v)—11.5 psia (water at 200°F)
Calculated required C_g—70

Non-Cavitating

$SPL_{\Delta P}$	=	81 (value from page 3-52)
SPL_{Cv}	=	18 (value from page 3-53)
SPL_K	=	−32.9 (value from page 3-53)
SPL_{Km}	=	.7 (value from page 3-54)
SPL_G	=	0 (value from page 3-55)
SPL	=	66.8 dBA

Cavitating

$SPL_{\Delta P}$	=	107 (value from page 3-52)
SPL_{Cv}	=	18 (value from page 3-53)
SPL_K	=	−32.9 (value from page 3-53)
SPL_{AR}	=	−8 (value from page 3-54)

84.1 dBA

The estimated sound pressure is 84 dBA.

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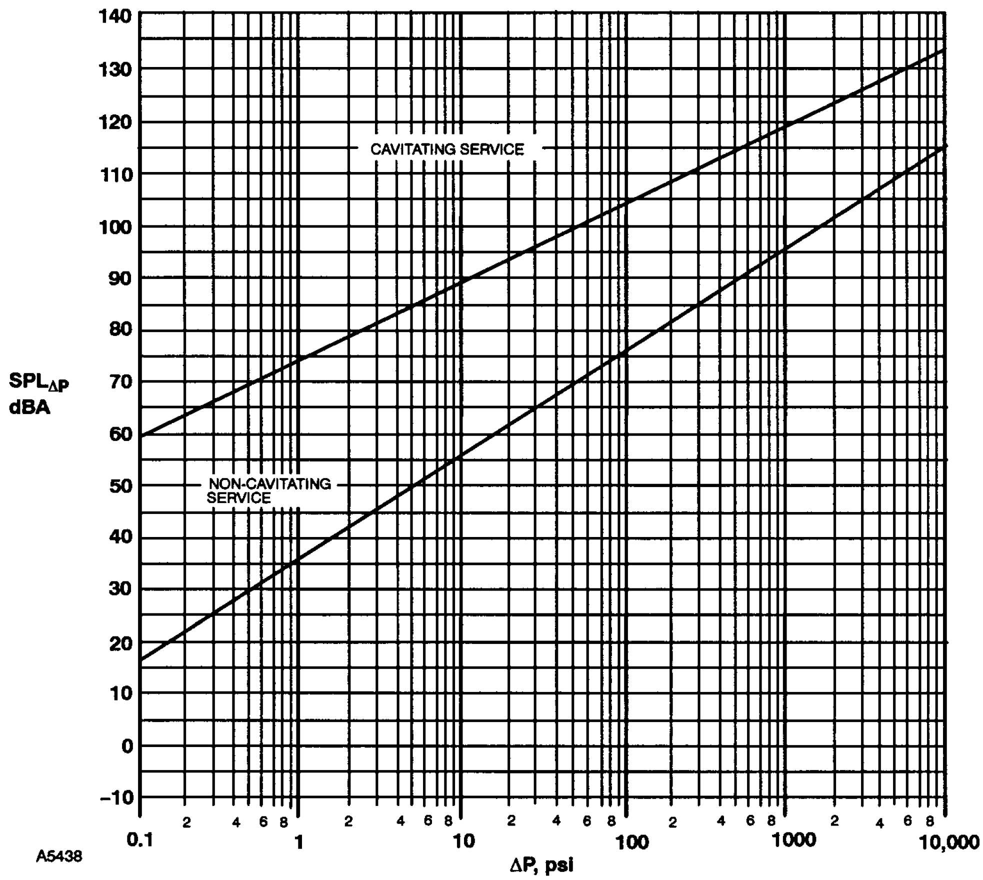
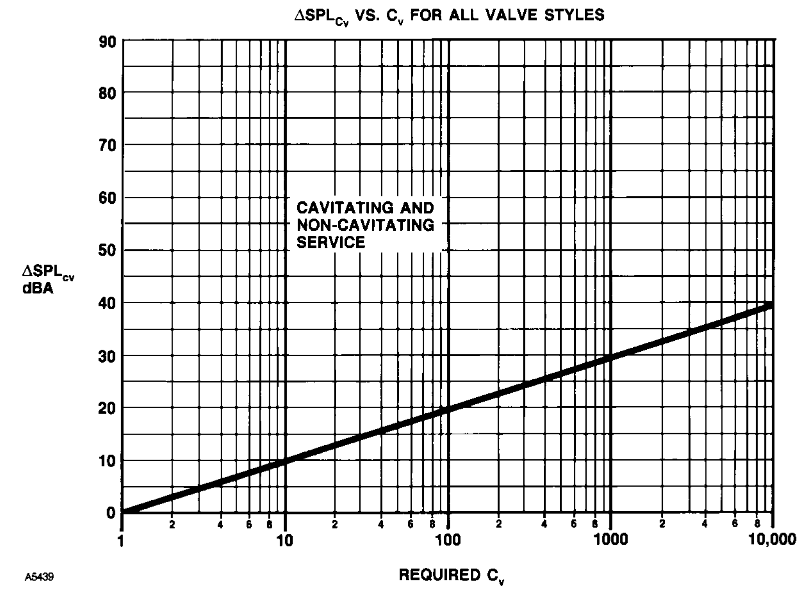
$SPL_{\Delta P}$ vs ΔP For All Valve Styles





ΔSPL_K

Nominal Pipe Size, Inch	Pipe Schedule												
	10	20	30	40	60	80	100	120	140	160	STD	XS	XXS
1	- - -	- - -	- - -	−48.8	- - -	−52.1	- - -	- - -	- - -	−56.1	−48.8	−52.1	−61.1
1-1/2	- - -	- - -	- - -	−42.8	- - -	−46.1	- - -	- - -	- - -	−49.9	−42.8	−46.1	−54.3
2	- - -	- - -	- - -	−38.7	- - -	−42.8	- - -	- - -	- - -	−47.7	−39.3	−42.6	−50.6
3	- - -	- - -	- - -	−35.9	- - -	−39.2	- - -	- - -	- - -	−43.1	−35.9	−39.2	−46.7
4	- - -	- - -	- - -	−32.9	- - -	−36.3	- - -	−38.9	- - -	−40.9	−32.9	−36.3	−43.5
6	- - -	- - -	- - -	−29.5	- - -	−33.5	- - -	−36.1	- - -	−38.5	−29.5	−33.5	−40.4
8	- - -	−25.7	−26.6	−27.9	−30.1	−32.0	−33.6	−35.4	−36.6	−37.7	−27.9	−32.0	−37.3
10	- - -	−23.5	−25.4	−26.9	−29.8	−31.4	−33.1	−34.7	−36.3	−37.4	−26.9	−29.8	- - -
12	- - -	−22	−24.5	−26.3	−29.3	−31.1	−33.0	−34.6	−35.7	−37.2	−25.6	−28.2	- - -
14	−21.2	−23.1	−24.8	−26.2	−28.9	−31.1	−33.1	−34.4	−35.9	−37	−24.8	−27.4	- - -
16	−20.0	−22	−23.6	−26.2	−28.6	−30.9	−32.8	−34.4	−35.9	−36.9	−23.6	−26.2	- - -
18	−19	−21	−24	−26.2	−28.8	−30.9	−32.8	−34.4	−35.6	−36.9	−22.6	−25.2	- - -
20	−18.2	−21.8	−24.3	−25.8	−28.7	−30.8	−32.8	−34.3	−35.8	−36.9	−21.8	−24.3	- - -
24	−16.7	−20.3	−23.9	−25.8	−28.7	−30.8	−32.9	−34.5	−35.7	−37.0	−20.3	−22.8	- - -
30	−16.9	−21.1	−23.1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−18.6	−21.1	- - -
36	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−17.2	−19.7	- - -
42	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−16.1	−18.6	- - -
44	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−15.7	−18.3	- - -
48	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−15.1	−17.6	- - -
52	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−14.6	−17.1	- - -
56	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−14.1	−16.6	- - -
60	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	−13.6	−16.1	- - -

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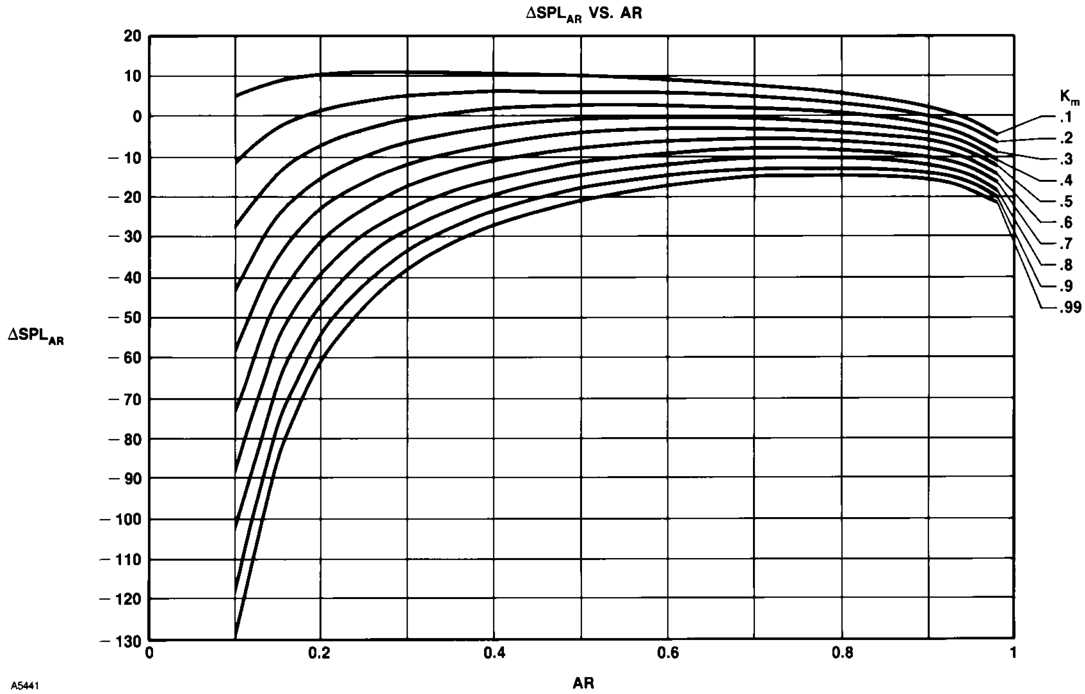
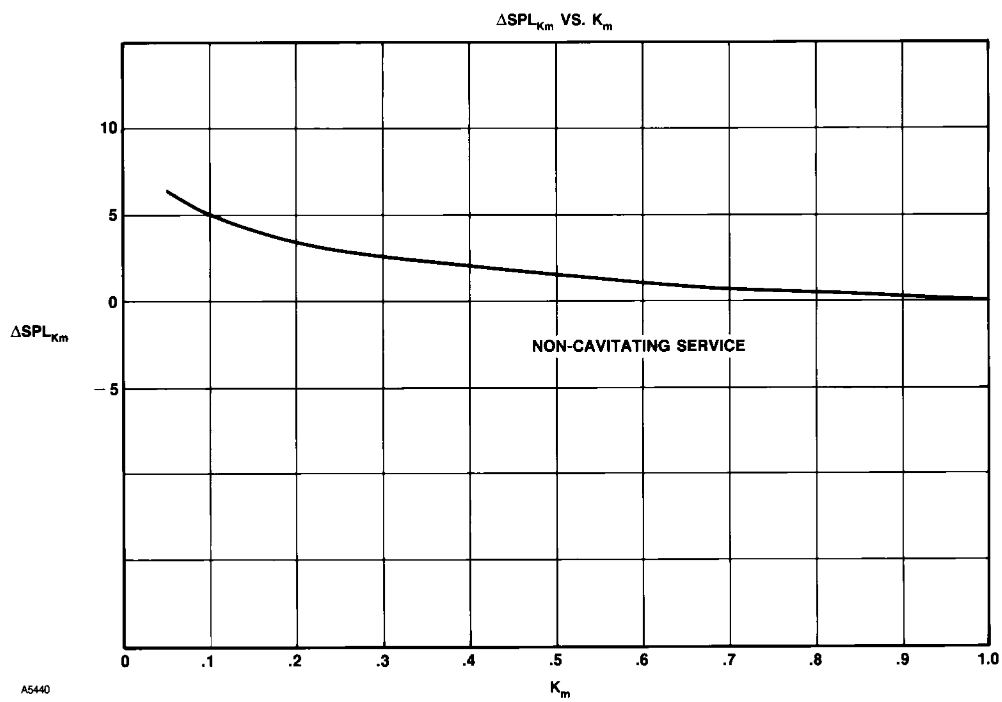
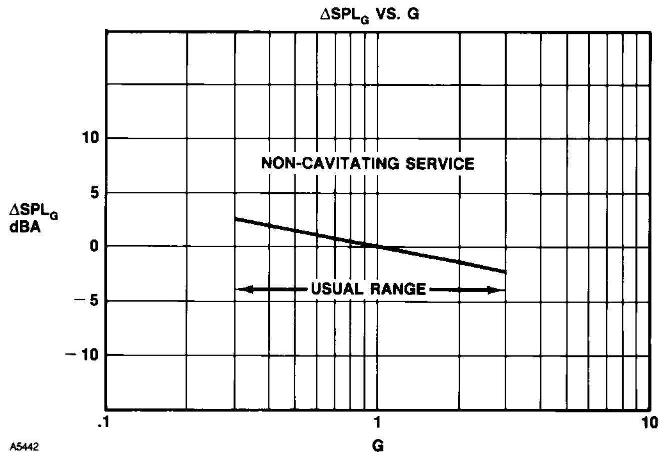
ΔSPL_{AR} vs AR and ΔSPL_{Km} vs. K_m






ΔSPLG VS. G
10
5
0
− 5
− 10
ΔSPLG
dBA
NON-CAVITATING SERVICE
USUAL RANGE
.1
1
10
G
A5442