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The Influence of the AGS Beam Parameters on the Beam Parameters at the RHIC Injection Point

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Brookhaven National Laboratory

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The change of the AGS ejected beam parameter will influence the injection efficiency of RHIC, cause phase space dilution and decrease the luminosity of RHIC. Although when there is some change in the AGS ejected beam parameters, one can tune the lattice of the beam transport line to match the injection requirement of RHIC but it is difficult to tune the transport line if the ejected beam parameters change from pulse to pulse. And our knowledge about the ejected beam parameters is within some accuracy, so the tune accuracy is limited also. The changes of the beam parameters at the RHIC injection point caused by the changes of the AGS ejected beam parameters have been calculated and summarized in this note. The lattice of the beam transport line from AGS to RHIC is described in reference 1.

In this note β_{xo}, α_{xo}, β_{yo}, α_{yo}, D_{xo}, D'_{xo}, D_{yo} and D'_{yo} are the Twiss parameters of AGS ejected beam. β_{xf}, α_{xf}, β_{yf}, α_{yf}, D_{xf}, D'_{xf}, D_{yf}, and D'_{yf} are the Twiss parameters at the RHIC injection point. Their nominal values are as following:

β_{xo}= 37.59m, α_{xo}= -4.778, β_{yo}= 8.05m, α_{yo}= 1.053, D_{xo}= -2.96m, D'_{xo} =-0.295, D_{yo}= 0.0m, D'_{yo}=0.0.

β_{xf}=9.09m, α_{xf}=0.0, β_{yf}=49.81m, α_{yf}=0.0, D_{xf}=-0.781m, D'_{xf}=0.0.

F_x and F_y are phase space dilution factor in the x-x' plane and y-y' plane respactively due to the mismatch at the RHIC injection point. And

$$F = \frac{A}{\epsilon} = \frac{1}{2}\left[\left(\frac{\beta_N}{\beta_f} + \frac{\beta_f}{\beta_N} + \alpha_N^2 \frac{\beta_N}{\beta_f}\right) + \sqrt{\left(\frac{\beta_N}{\beta_f} + \frac{\beta_f}{\beta_N} + \alpha_N^2 \frac{\beta_N}{\beta_f}\right)^2 - 4}\right]$$

where A is the required RHIC admittance in order to include the injected beam with emittance ϵ and beam parameters β_f and α_f. β_N is the nominal β value at RHIC injection point ($\alpha_N = 0.0$). The phase space dilution factor due to mismatch of the dispersion fuctions is expressed as following:

$$F = \frac{A}{\epsilon} = \left[1 + \frac{|\delta|}{\sqrt{\epsilon}} \sqrt{\gamma_N D^2 + \beta_N D'^2}\right]^2$$

where $D = D_N - D_f$ and $D' = D'_N - D'_f$. Here D_N and D'_N are the nominal values at RHIC injection point and D_f and D'_f are the parameters of the injected beam.

The results are summarized in the following tables:

β_{xo}, α_{xo}, β_{yo} and α_{yo} change ±10%

β_{xo} (m)	α_{xo}	β_{yo}(m)	α_{yo}	β_{xf}(m)	α_{xf}	β_{yf}(m)	α_{yf}	F_x	F_y
42.63(+10%)	-4.778(+0.0)	8.85(+10%)	1.053(+0.0)	7.629	0.507	43.585	0.035	1.774	1.149
33.83(-10%)	-4.778(+0.0)	7.25(-10%)	1.053(+0.0)	11.219	-0.543	57.861	-0.02	1.692	1.16
37.59(+0.0)	-4.310(+10%)	8.05(+0.0)	1.158(+10%)	7.294	0.332	53.281	-0.081	1.536	1.136
37.59(+0.0)	-5.255(-10%)	8.05(+0.0)	0.948(-10%)	11.992	-0.481	47.26	0.090	1.645	1.112
33.83(-10%)	-4.310(+10%)	7.25(-10%)	1.158(+10%)	8.665	-0.066	62.529	-0.099	1.087	1.277
42.63(+10%)	-5.255(-10%)	8.85(+10%)	0.948(-10%)	9.759	0.187	41.933	0.129	1.21	1.248
42.63(+10%)	-4.310(+10%)	8.85(+10%)	1.158(+10%)	5.813	0.718	46.145	-0.054	2.63	1.08
33.83(-10%)	-5.255(-10%)	7.25(-10%)	0.948(-10%)	14.12	-1.152	57.861	-0.020	2.678	1.163

D_{xo} and D'_{xo} change ±10%

D_{xo}(m)	D'_{xo}	D_{xf}(m)	D'_{xf}	F^*_x
-2.664(+10%)	-0.295(+0.0)	-0.727	0.079	1.32
-3.256(-10%)	-0.295(+0.0)	-0.828	-0.074	1.30
-2.96(+0.0)	-0.265(+10%)	-0.926	-0.054	1.23
-2.96(+0.0)	-0.324(-10%)	-0.626	0.059	1.24
-3.256(-10%)	-0.265(+10%)	-0.980	-0.131	1.59
-2.664(+10%)	-0.324(-10%)	-0.575	0.135	1.59
-2.664(+10%)	-0.265(+10%)	-0.879	0.022	1.09
-3.256(-10%)	-0.324(-10%)	-0.677	-0.018	1.08

D_{yo} changes ±0.2m, D'_{yo} changes ±0.1.

D_{yo}(m)	D'_{yo}	D_{yf}(m)	D'_{yf}
0.2	0.0	0.191	-0.005
-0.2	0.0	-0.507	0.02
0.0	0.1	1.75	-0.005
0.0	-0.1	-2.066	0.02
-0.2	0.1	1.401	0.008
0.2	-0.1	-1.717	0.007
0.2	0.1	2.099	-0.017
-0.2	-0.1	-2.415	0.032

* For particles with momentum deviation $\delta = \frac{\Delta p}{p} = 0.001$.

References:

1. J. Claus and H. Foelche, Beam transfer from AGS to RHIC. RHIC Technical Note No. 47, 1988.
2. J. Claus, RHIC Injection. Accelerator Physics Division Meeting, Talk 63, 1988.

Addendum to RHIC-RD-14, " The Influence of the AGS Beam Parameters on the Beam Parameters at the RHIC Injection Point", Jianming Xu, January ,1990

1. More datas have been calculated and summarized in figure 1, 2 and 3. The changing ranges of α and D'_x are extended to ±50%.

2. The expressions for dilution factor F are valid for $\alpha_N = 0$, the case for RHIC.

3. The dilution factor due to β, α mismatch is:

$$F = \frac{A}{\epsilon} = \frac{1}{2}\left[\left(\frac{\beta_N}{\beta_f} + \frac{\beta_f}{\beta_N} + \alpha_f^2 \frac{\beta_N}{\beta_f}\right) + \sqrt{\left(\frac{\beta_N}{\beta_f} + \frac{\beta_f}{\beta_N} + \alpha_f^2 \frac{\beta_N}{\beta_f}\right)^2 - 4}\right]$$

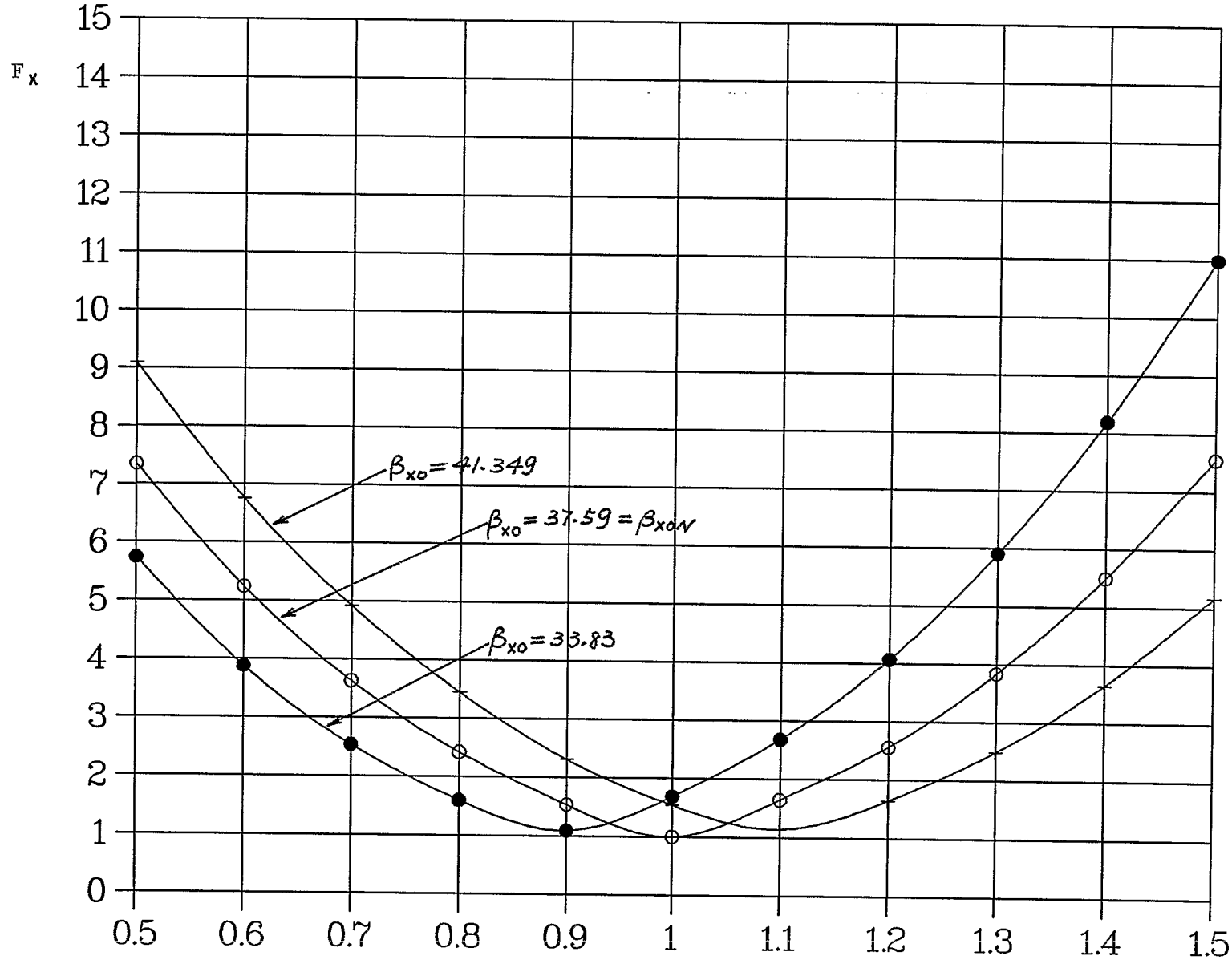
Fx
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
$\beta_{xo}=41.349$
$\beta_{xo}=37.59=\beta_{xoN}$
$\beta_{xo}=33.83$
α_{xo}/α_{xoN}
$\alpha_{xoN}=-4.778$

Figure 1

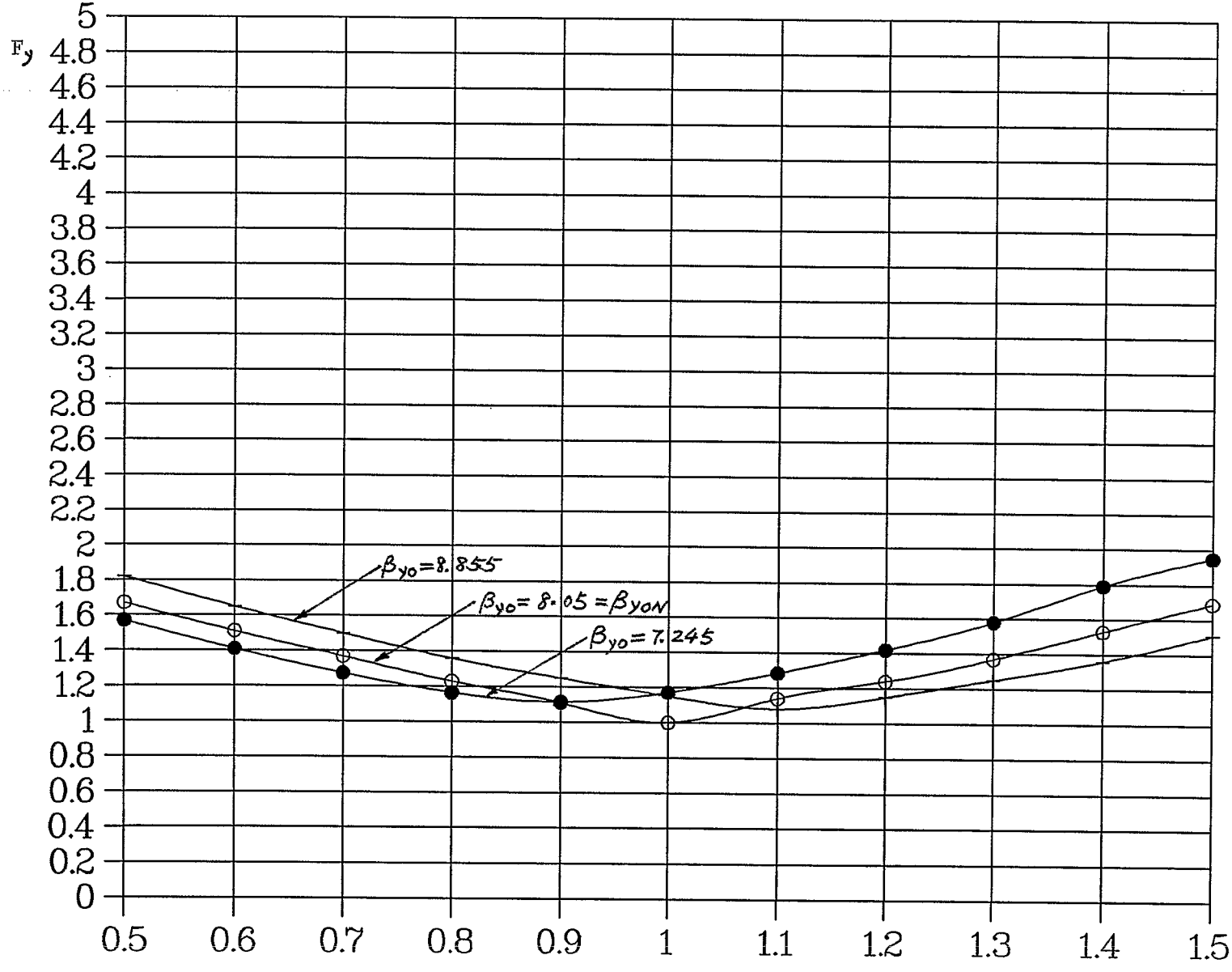
F_y
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
$\beta_{yo}=8.855$
$\beta_{yo}=8.05=\beta_{yoN}$
$\beta_{yo}=7.245$
α_{yo}/α_{yoN}
$\alpha_{yoN}=1.053$

Figure 2

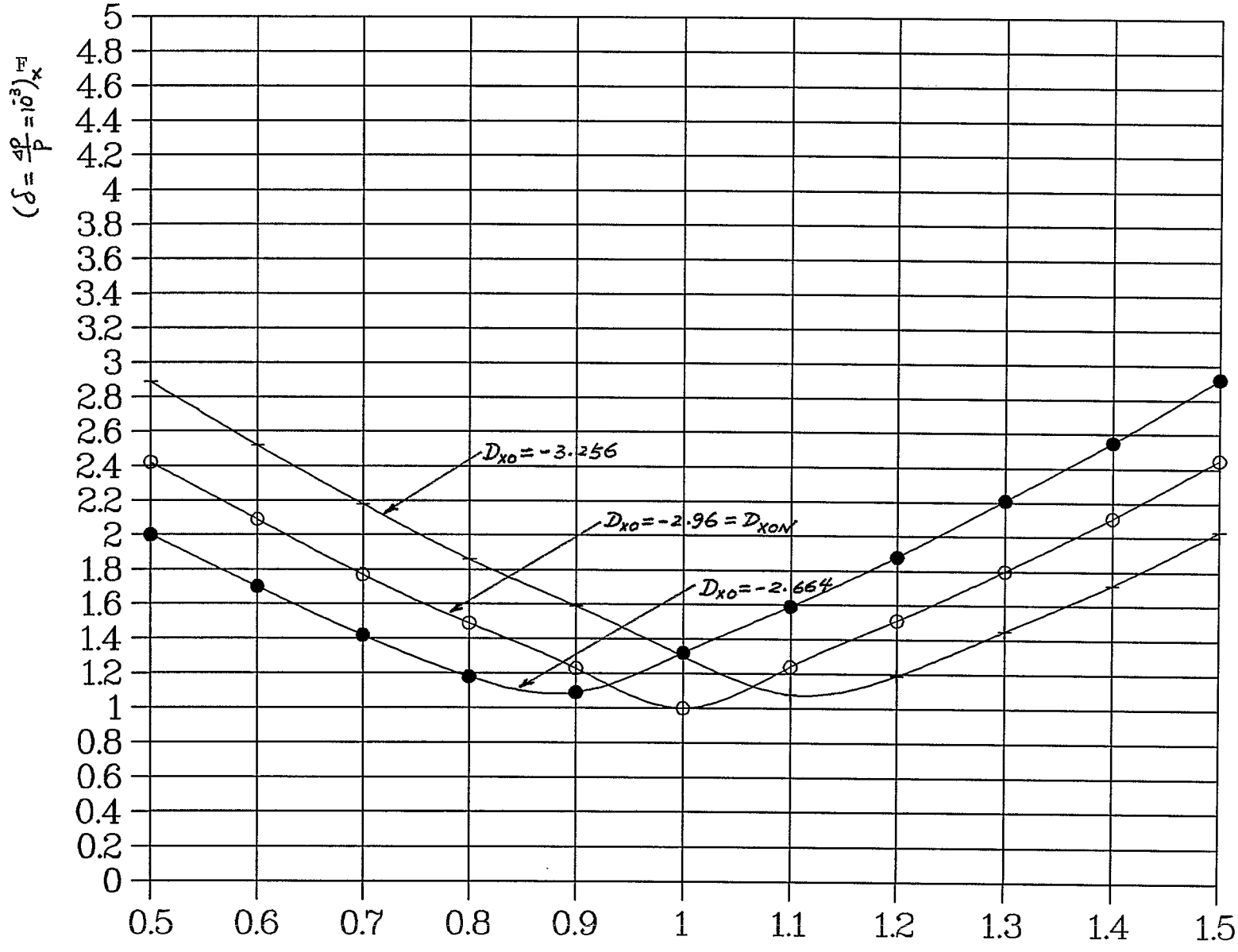
$(\delta = \frac{\Delta p}{p} \times 10^3)_x^F$
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
$D_{xo} = -3.256$
$D_{xo} = -2.96 = D_{xoN}$
$D_{xo} = -2.664$
D'_{xo}/D'_{xoN}
$D'_{xoN} = -0.295$

Figure 3