Westaflex Australia Pty. Ltd.

Measurement of Friction Loss of Flexible Ducting

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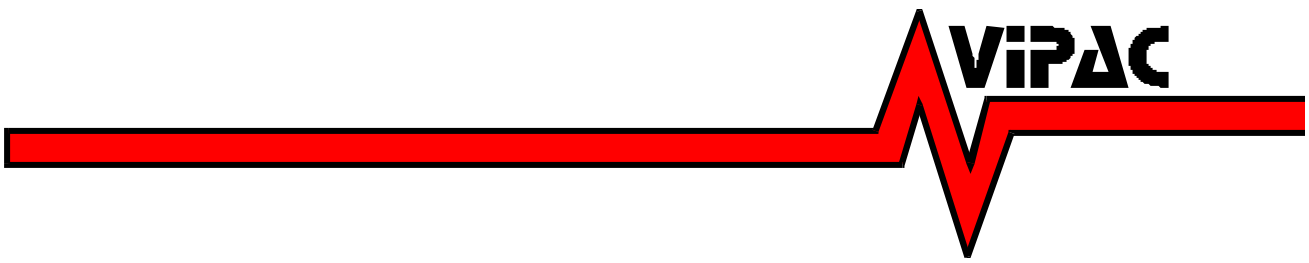
N.A.T.A. Report No. 302398/1
Prepared by
Vipac Engineers & Scientists Ltd
October, 2000



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Measurement of Static Insertion Loss of Flexible Ducting

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KEY WORDS:	Friction Loss, Flexible Duct

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1.0 INTRODUCTION

This report presents the results of Friction Loss measurements carried out for the various flexible duct samples described in Table 1 below. Refer to Appendix A for photographs of each sample type.

This report is issued as a NATA certified report under the terms of Vipac's NATA registration No's 1163 and 1506.

Table 1:Flexible Duct Samples for Friction Loss Testing, Nominal Length 3m

Sample #	Name	Description	Tested Sizes, Inner Diameter in mm
1	TLP	Tyvek Laminated Polypropylene porous inner sleeve, black plastic outer, interlocked spiral duct, R0.6 insulation.	150, 300
2	Q FLEX	Non-woven porous fabric inner, black plastic outer, interlocked spiral duct, R1 insulation	150, 300
3	UNILOK FR1 R1	Black plastic inner and outer, interlocked spiral duct, R1 insulation	150, 300
4	UNILOK FR1 R1 AI	Black plastic perforated inner, black plastic outer, interlocked spiral duct, R1 insulation	150, 300
5	VFLEX	Foil inner and outer, glued duct, R0.6 insulation	150, 300

Note: Samples 2, 3 and 4 are also available with foil outer sleeve. These products are known as QSFLEX, UNILOK S R1, and UNILOK S R1 AI, respectively. Due to similarity the data in this report can be applied to the equivalent products with the foil outer sleeve.

2.0 APPLICABLE STANDARDS

The set up and measurement procedure for determination of Friction Loss was in general accordance with Air Diffusion Council Standard FD 72-R1: "Flexible Air Duct Test Code".

3.0 TEST SET UP AND PROCEDURE

Each nominally 3m long sample was layed straight, and at various air flows the pressure drop (friction loss) across the sample was measured. Each sample was then oriented with a 90deg bend of curvature R/D = 4 and R/D = 1.5 respectively, and at various air flow rates the pressure drop across the sample was measured.

R = centreline bend radius; D = duct inner sleeve diameter

For the 90deg bend orientations, the length of the straight end segments of the duct were measured. By calculation the pressure drop of the bend only was then determined.

The length of the duct forming the bend was determined, and the friction loss of an equivalent straight length calculated. This was subtracted from the bend only pressure drop, to give the additional pressure drop due to the bend. The equivalent additional straight length due to the bend was then calculated.

The environmental test conditions in the Reverberation Room did not vary during the test by greater than the following variations:

Temperature	± 5.0 °C
Relative Humidity	± 5%

4.0 INSTRUMENTATION

INSTRUMENT	MAKE	MODEL	CALIBRATION	SERIAL NO
Manometers	Airflow Develop.	Type 504	Gas & Fuel Vic.	PM6-168 PM6-171
Orifice Plates	Vipac	-	Vipac	-

5.0 ORDERS OF ACCURACY

Friction Loss: ± 5% or 0.5 Pa whichever is greater

Airflow: ± 5%

6.0 RESULTS

The results obtained are shown in the attached Test Certificates.

Appendix B shows tabulated data for a comprehensive range of flow rates as calculated from the measurement data.

Appendix C shows comparison plots of friction loss for straight duct runs.

Report Prepared by:
VIPAC ENGINEERS AND SCIENTISTS LTD.

.....	.....
GREG THEODORIDIS	NORM BRONER
PROJECT ENGINEER	**N.A.T.A. SIGNATORY**

TEST CERTIFICATE No. 1 - 150mm TLP

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: WESTAFLEX AUSTRALIA PTY. LTD.
TESTED BY: VIPAC ENGINEERS & SCIENTISTS LTD
TEST DATE: 5-7/10/2000
CLIENT: WESTAFLEX AUSTRALIA PTY. LTD.
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 0.6
STANDARD: AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1
NOMINAL VELOCITY BASED ON 150mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 3.1m

Measured Performance for Tested Length					
Flow Rate (l/s)	**84**	**154**	**196**	**237**	**269**
Nominal Velocity (m/s)	4.8	8.7	11.1	13.4	15.2
Friction Loss (Pa)	40	133	222	328	425
Calculated Friction Loss per Metre Length (Pa)	13	43	72	106	137

90° BEND (R/D = 4), Total Length of Straight End Segments = 1.79m

Measured Performance for Tested Length					
Flow Rate (l/s)	**70**	**107**	**161**	**204**	**259**
Nominal Velocity (m/s)	4.0	6.1	9.1	11.5	14.7
Friction Loss (Pa)	54	132	309	515	800
Calculated:					
Friction Loss of Bend Only (Pa)	38	94	223	375	572
Friction Loss of Equivalent Straight Length (Pa)	12	27	63	102	167
Equivalent Additional Straight Length due to Bend(m)	3.0	3.2	3.3	3.5	3.2

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 2.44m

Measured Performance for Tested Length					
Flow Rate (l/s)	**63**	**125**	**171**	**215**	**264**
Nominal Velocity (m/s)	3.6	7.1	9.7	12.2	15.0
Friction Loss (Pa)	43	178	329	517	802
Calculated:					
Friction Loss of Bend Only (Pa)	25	108	195	304	478
Friction Loss of Equivalent Straight Length (Pa)	5	19	36	58	88
Equivalent Additional Straight Length due to Bend(m)	2.9	3.1	2.9	2.8	2.9

_____ _____

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PROJECT ENGINEER

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TEST CERTIFICATE No. 2 - 150mm VFLEX

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: WESTAFLEX AUSTRALIA PTY. LTD.
TESTED BY: VIPAC ENGINEERS & SCIENTISTS LTD
TEST DATE: 5-7/10/2000
CLIENT: WESTAFLEX AUSTRALIA PTY. LTD.
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 0.6
STANDARD: AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1
NOMINAL VELOCITY BASED ON 150mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 3.33m

Measured Performance for Tested Length

Flow Rate (l/s)	**102**	**161**	**199**	**230**	**267**
Nominal Velocity (m/s)	5.8	9.1	11.3	13.0	15.1
Friction Loss (Pa)	31	80	127	171	237
Calculated Friction Loss per Metre Length (Pa)	9	24	38	51	71

90° BEND (R/D = 4), Total Length of Straight End Segments = 2.12m

Measured Performance for Tested Length

Flow Rate (l/s)	**94**	**165**	**210**	**239**	**284**
Nominal Velocity (m/s)	5.3	9.4	11.9	13.5	16.1
Friction Loss (Pa)	37	114	196	254	360
Calculated:					
Friction Loss of Bend Only (Pa)	21	59	106	135	190
Friction Loss of Equivalent Straight Length (Pa)	9	31	51	68	97
Equivalent Additional Straight Length due to Bend(m)	1.4	1.1	1.3	1.2	1.2

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 2.72m

Measured Performance for Tested Length

Flow Rate (l/s)	**119**	**174**	**215**	**239**	**278**
Nominal Velocity (m/s)	6.7	9.9	12.2	13.5	15.7
Friction Loss (Pa)	63	139	217	273	372
Calculated:					
Friction Loss of Bend Only (Pa)	28	61	95	120	163
Friction Loss of Equivalent Straight Length (Pa)	8	17	27	34	47
Equivalent Additional Straight Length due to Bend(m)	1.6	1.5	1.5	1.5	1.5

_____ _____

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TEST CERTIFICATE No. 3 - 150mm QFLEX

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: WESTAFLEX AUSTRALIA PTY. LTD.
TESTED BY: VIPAC ENGINEERS & SCIENTISTS LTD
TEST DATE: 5-7/10/2000
CLIENT: WESTAFLEX AUSTRALIA PTY. LTD.
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 1
STANDARD: AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1
NOMINAL VELOCITY BASED ON 150mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 3.16m

Measured Performance for Tested Length

Flow Rate (l/s)	**107**	**161**	**201**	**236**	**277**
Nominal Velocity (m/s)	6.1	9.1	11.4	13.4	15.7
Friction Loss (Pa)	39	88	138	185	254
Calculated Friction Loss per Metre Length (Pa)	12	28	44	59	80

90° BEND (R/D = 4), Total Length of Straight End Segments = 1.91m

Measured Performance for Tested Length

Flow Rate (l/s)	**94**	**164**	**200**	**228**	**262**
Nominal Velocity (m/s)	5.3	9.3	11.3	12.9	14.8
Friction Loss (Pa)	52	157	242	308	411
Calculated:					
Friction Loss of Bend Only (Pa)	33	101	158	200	269
Friction Loss of Equivalent Straight Length (Pa)	12	37	55	71	93
Equivalent Additional Straight Length due to Bend(m)	2.1	2.1	2.4	2.3	2.4

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 2.48m

Measured Performance for Tested Length

Flow Rate (l/s)	**88**	**142**	**184**	**221**	**266**
Nominal Velocity (m/s)	5.0	8.1	10.4	12.5	15.1
Friction Loss (Pa)	55	145	233	330	470
Calculated:					
Friction Loss of Bend Only (Pa)	34	89	141	198	280
Friction Loss of Equivalent Straight Length (Pa)	6	15	25	36	52
Equivalent Additional Straight Length due to Bend(m)	3.2	3.3	3.1	3.0	3.0

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TEST CERTIFICATE No. 4 - 150mm UNILOK FR1 R1 (PLAIN)

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: WESTAFLEX AUSTRALIA PTY. LTD.
TESTED BY: VIPAC ENGINEERS & SCIENTISTS LTD
TEST DATE: 5-7/10/2000
CLIENT: WESTAFLEX AUSTRALIA PTY. LTD.
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 1
STANDARD: AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1
NOMINAL VELOCITY BASED ON 150mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 3.24m

Measured Performance for Tested Length					
Flow Rate (l/s)	**96**	**159**	**204**	**240**	**269**
Nominal Velocity (m/s)	5.5	9.0	11.5	13.6	15.3
Friction Loss (Pa)	25	67	110	151	198
Calculated Friction Loss per Metre Length (Pa)	8	21	34	47	61

90° BEND (R/D = 4), Total Length of Straight End Segments = 2.12m

Measured Performance for Tested Length					
Flow Rate (l/s)	**94**	**153**	**203**	**240**	**279**
Nominal Velocity (m/s)	5.3	8.6	11.5	13.6	15.8
Friction Loss (Pa)	33	90	157	220	295
Calculated:					
Friction Loss of Bend Only (Pa)	18	51	88	123	163
Friction Loss of Equivalent Straight Length (Pa)	8	21	37	51	70
Equivalent Additional Straight Length due to Bend(m)	1.5	1.6	1.6	1.5	1.5

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 2.74m

Measured Performance for Tested Length					
Flow Rate (l/s)	**99**	**151**	**203**	**236**	**264**
Nominal Velocity (m/s)	5.6	8.6	11.5	13.4	15.0
Friction Loss (Pa)	48	111	201	276	355
Calculated:					
Friction Loss of Bend Only (Pa)	26	61	111	154	203
Friction Loss of Equivalent Straight Length (Pa)	4	9	16	22	28
Equivalent Additional Straight Length due to Bend(m)	2.9	2.9	2.9	3.0	3.1

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TEST CERTIFICATE No. 5 - 150mm UNILOK FR1 R1 Al (ACOUSTIC)

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: WESTAFLEX AUSTRALIA PTY. LTD.
TESTED BY: VIPAC ENGINEERS & SCIENTISTS LTD
TEST DATE: 5-7/10/2000
CLIENT: WESTAFLEX AUSTRALIA PTY. LTD.
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 1
STANDARD: AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1
NOMINAL VELOCITY BASED ON 150mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 2.87m

Measured Performance for Tested Length					
Flow Rate (l/s)	**81**	**144**	**188**	**225**	**261**
Nominal Velocity (m/s)	4.6	8.2	10.6	12.7	14.8
Friction Loss (Pa)	33	96	165	234	319
Calculated Friction Loss per Metre Length (Pa)	11	33	57	82	111

90° BEND (R/D = 4), Total Length of Straight End Segments = 1.51m

Measured Performance for Tested Length					
Flow Rate (l/s)	**66**	**101**	**154**	**215**	**262**
Nominal Velocity (m/s)	3.7	5.7	8.7	12.2	14.9
Friction Loss (Pa)	43	107	241	453	680
Calculated:					
Friction Loss of Bend Only (Pa)	32	82	183	342	516
Friction Loss of Equivalent Straight Length (Pa)	10	23	53	100	147
Equivalent Additional Straight Length due to Bend(m)	3.0	3.5	3.4	3.3	3.4

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 2.04m

Measured Performance for Tested Length					
Flow Rate (l/s)	**81**	**107**	**154**	**216**	**264**
Nominal Velocity (m/s)	4.6	6.1	8.7	12.2	15.0
Friction Loss (Pa)	66	122	241	469	685
Calculated:					
Friction Loss of Bend Only (Pa)	43	83	162	317	461
Friction Loss of Equivalent Straight Length (Pa)	9	16	32	62	91
Equivalent Additional Straight Length due to Bend(m)	3.1	3.5	3.4	3.4	3.4

_____ _____

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TEST CERTIFICATE No. 6 - 300mm TLP

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: **WESTAFLEX AUSTRALIA PTY. LTD.**
TESTED BY: **VIPAC ENGINEERS & SCIENTISTS LTD**
TEST DATE: **5-7/10/2000**
CLIENT: **WESTAFLEX AUSTRALIA PTY. LTD.**
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 0.6
STANDARD: **AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1**
NOMINAL VELOCITY BASED ON 300mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 3m

Measured Performance for Tested Length					
Flow Rate (l/s)	**414**	**540**	**693**	**840**	**995**
Nominal Velocity (m/s)	5.9	7.7	9.8	11.9	14.1
Friction Loss (Pa)	30	50	82	125	168
Calculated Friction Loss per Metre Length (Pa)	10	17	27	42	56

90° BEND (R/D = 4), Total Length of Straight End Segments = 0.67m

Measured Performance for Tested Length					
Flow Rate (l/s)	**383**	**536**	**647**	**799**	**968**
Nominal Velocity (m/s)	5.4	7.6	9.2	11.3	13.7
Friction Loss (Pa)	47	92	138	212	315
Calculated:					
Friction Loss of Bend Only (Pa)	41	81	122	187	279
Friction Loss of Equivalent Straight Length (Pa)	20	39	56	86	125
Equivalent Additional Straight Length due to Bend(m)	2.5	2.5	2.7	2.8	2.9

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 1.94m

Measured Performance for Tested Length					
Flow Rate (l/s)	**402**	**598**	**722**	**849**	**987**
Nominal Velocity (m/s)	5.7	8.5	10.2	12.0	14.0
Friction Loss (Pa)	49	105	153	206	283
Calculated:					
Friction Loss of Bend Only (Pa)	31	65	95	126	175
Friction Loss of Equivalent Straight Length (Pa)	10	22	32	44	59
Equivalent Additional Straight Length due to Bend(m)	2.2	2.1	2.1	2.0	2.1

_____ _____

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TEST CERTIFICATE No. 7 - 300mm VFLEX

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: WESTAFLEX AUSTRALIA PTY. LTD.
TESTED BY: VIPAC ENGINEERS & SCIENTISTS LTD
TEST DATE: 5-7/10/2000
CLIENT: WESTAFLEX AUSTRALIA PTY. LTD.
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 0.6
STANDARD: AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1
NOMINAL VELOCITY BASED ON 300mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 2.8m

Measured Performance for Tested Length					
Flow Rate (l/s)	**526**	**647**	**753**	**855**	**992**
Nominal Velocity (m/s)	7.4	9.2	10.7	12.1	14.0
Friction Loss (Pa)	28	43	57	75	98
Calculated Friction Loss per Metre Length (Pa)	10	15	20	27	35

90° BEND (R/D = 4), Total Length of Straight End Segments = 0.67m

Measured Performance for Tested Length					
Flow Rate (l/s)	**460**	**623**	**736**	**885**	**981**
Nominal Velocity (m/s)	6.5	8.8	10.4	12.5	13.9
Friction Loss (Pa)	29	55	76	111	138
Calculated:					
Friction Loss of Bend Only (Pa)	24	45	63	92	115
Friction Loss of Equivalent Straight Length (Pa)	17	30	42	60	74
Equivalent Additional Straight Length due to Bend(m)	0.9	1.1	1.1	1.1	1.2

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 1.82m

Measured Performance for Tested Length					
Flow Rate (l/s)	**454**	**590**	**732**	**824**	**981**
Nominal Velocity (m/s)	6.4	8.3	10.4	11.7	13.9
Friction Loss (Pa)	31	52	84	107	147
Calculated:					
Friction Loss of Bend Only (Pa)	17	29	48	62	84
Friction Loss of Equivalent Straight Length (Pa)	7	12	19	24	34
Equivalent Additional Straight Length due to Bend(m)	1.3	1.3	1.5	1.5	1.4

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TEST CERTIFICATE No. 8 - 300mm Q FLEX

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: WESTAFLEX AUSTRALIA PTY. LTD.
TESTED BY: VIPAC ENGINEERS & SCIENTISTS LTD
TEST DATE: 5-7/10/2000
CLIENT: WESTAFLEX AUSTRALIA PTY. LTD.
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 1
STANDARD: AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1
NOMINAL VELOCITY BASED ON 300mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 3m

Measured Performance for Tested Length					
Flow Rate (l/s)	**517**	**678**	**793**	**913**	**1007**
Nominal Velocity (m/s)	7.3	9.6	11.2	12.9	14.3
Friction Loss (Pa)	33	54	73	95	116
Calculated Friction Loss per Metre Length (Pa)	11	18	24	32	39

90° BEND (R/D = 4), Total Length of Straight End Segments = 0.93m

Measured Performance for Tested Length					
Flow Rate (l/s)	**363**	**554**	**689**	**831**	**1001**
Nominal Velocity (m/s)	5.1	7.8	9.8	11.8	14.2
Friction Loss (Pa)	33	76	119	170	233
Calculated:					
Friction Loss of Bend Only (Pa)	28	64	102	145	198
Friction Loss of Equivalent Straight Length (Pa)	12	26	39	55	78
Equivalent Additional Straight Length due to Bend(m)	2.9	3.1	3.3	3.4	3.2

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 2.06m

Measured Performance for Tested Length					
Flow Rate (l/s)	**370**	**526**	**707**	**846**	**995**
Nominal Velocity (m/s)	5.2	7.4	10.0	12.0	14.1
Friction Loss (Pa)	38	76	139	194	265
Calculated:					
Friction Loss of Bend Only (Pa)	26	53	98	137	188
Friction Loss of Equivalent Straight Length (Pa)	5	11	19	26	35
Equivalent Additional Straight Length due to Bend(m)	3.5	3.7	4.1	4.0	4.1

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TEST CERTIFICATE No. 9 - 300mm UNILOK FR1 R1 (PLAIN)

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: WESTAFLEX AUSTRALIA PTY. LTD.
TESTED BY: VIPAC ENGINEERS & SCIENTISTS LTD
TEST DATE: 5-7/10/2000
CLIENT: WESTAFLEX AUSTRALIA PTY. LTD.
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 1
STANDARD: AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1
NOMINAL VELOCITY BASED ON 300mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 2.9m

Measured Performance for Tested Length					
Flow Rate (l/s)	**486**	**663**	**786**	**870**	**995**
Nominal Velocity (m/s)	6.9	9.4	11.1	12.3	14.1
Friction Loss (Pa)	26	47	66	80	104
Calculated Friction Loss per Metre Length (Pa)	9	16	23	28	36

90° BEND (R/D = 4), Total Length of Straight End Segments = 0.64m

Measured Performance for Tested Length					
Flow Rate (l/s)	**402**	**607**	**732**	**828**	**976**
Nominal Velocity (m/s)	5.7	8.6	10.4	11.7	13.8
Friction Loss (Pa)	33	77	113	142	202
Calculated:					
Friction Loss of Bend Only (Pa)	29	68	100	126	180
Friction Loss of Equivalent Straight Length (Pa)	14	31	45	57	78
Equivalent Additional Straight Length due to Bend(m)	2.4	2.7	2.8	2.8	2.9

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 1.94m

Measured Performance for Tested Length					
Flow Rate (l/s)	**363**	**545**	**689**	**834**	**968**
Nominal Velocity (m/s)	5.1	7.7	9.8	11.8	13.7
Friction Loss (Pa)	32	72	118	170	225
Calculated:					
Friction Loss of Bend Only (Pa)	22	50	84	121	159
Friction Loss of Equivalent Straight Length (Pa)	5	11	17	24	33
Equivalent Additional Straight Length due to Bend(m)	3.4	3.6	3.8	3.8	3.7

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Greg Theodoridis
PROJECT ENGINEER

Norm Broner
N.A.T.A. SIGNATORY

This laboratory is accredited by the National Association of Testing Authorities, Australia.

TEST CERTIFICATE No. 10 - 300mm UNILOK FR1 R1 AI (ACOUSTIC)

MEASUREMENT OF FRICTION LOSS OF FLEXIBLE DUCTS

SUPPLIED BY: WESTAFLEX AUSTRALIA PTY. LTD.
TESTED BY: VIPAC ENGINEERS & SCIENTISTS LTD
TEST DATE: 5-7/10/2000
CLIENT: WESTAFLEX AUSTRALIA PTY. LTD.
SAMPLE LENGTH: 3 METRES (NOMINAL)
INSULATION: R 1
STANDARD: AIR DIFFUSION COUNCIL FLEXIBLE AIR DUCT CODE FD 72-R1
NOMINAL VELOCITY BASED ON 300mm INNER SLEEVE DIAMETER (D)
R = CENTRELINE RADIUS OF BEND

FLOW RATE (l/s) versus FRICTION LOSS (Pa)

STRAIGHT LENGTH, Total Length = 2.84m

Measured Performance for Tested Length					
Flow Rate (l/s)	**449**	**577**	**783**	**992**	
Nominal Velocity (m/s)	6.4	8.2	11.1	14.0	
Friction Loss (Pa)	34	56	104	167	
Calculated Friction Loss per Metre Length (Pa)	12	20	37	59	

90° BEND (R/D = 4), Total Length of Straight End Segments = 0.58m

Measured Performance for Tested Length					
Flow Rate (l/s)	**334**	**507**	**689**	**846**	**981**
Nominal Velocity (m/s)	4.7	7.2	9.8	12.0	13.9
Friction Loss (Pa)	32	73	135	199	269
Calculated:					
Friction Loss of Bend Only (Pa)	28	64	119	174	236
Friction Loss of Equivalent Straight Length (Pa)	15	34	64	97	130
Equivalent Additional Straight Length due to Bend(m)	2.0	1.9	1.9	1.8	1.8

90° BEND (R/D = 1.5), Total Length of Straight End Segments = 1.7m

Measured Performance for Tested Length					
Flow Rate (l/s)	**342**	**502**	**670**	**802**	**981**
Nominal Velocity (m/s)	4.8	7.1	9.5	11.4	13.9
Friction Loss (Pa)	38	82	143	208	305
Calculated:					
Friction Loss of Bend Only (Pa)	26	57	97	143	207
Friction Loss of Equivalent Straight Length (Pa)	8	17	31	44	66
Equivalent Additional Straight Length due to Bend(m)	2.7	2.6	2.5	2.6	2.5

_____ _____

Greg Theodoridis
PROJECT ENGINEER

Norm Broner
N.A.T.A. SIGNATORY

This laboratory is accredited by the National Association of Testing Authorities, Australia.

The tests reported herein have been performed in accordance with its terms of accreditation. This

APPENDIX A

PHOTOGRAPHS OF EACH SAMPLE TYPE

(Note photographs are of the 150mm size)

Photo A1: TLP

Photo A2: Q FLEX

Photo A3: UNILOK FR1 R1

Photo A4: UNILOK FR1 R1 AI

Photo A5: VFLEX

APPENDIX B

TABULATED DATA FOR COMPREHENSIVE RANGE OF FLOW RATES

Table B1: Data for 150mm TLP

Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	18	35	53	71	88	106	124	141	159	177	194	212	230	247	265
Friction Loss per Linear metre (Pa/m)	1	2	5	9	14	21	28	37	47	58	71	85	100	116	134
Friction Loss of R/D=4 Bend Only (Pa)	2	9	22	40	63	92	127	168	215	268	327	392	463	541	624
Friction Loss of Equivalent Straight Length (Pa)	1	3	7	12	19	27	37	48	62	76	93	111	131	152	175
Equivalent additional Straight Length due to bend (m)	2.8	3.0	3.0	3.1	3.1	3.2	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.4	3.4
Friction Loss of R/D=1.5 Bend Only (Pa)	2	8	18	32	51	74	101	133	169	210	255	304	358	417	480
Friction Loss of Equivalent Straight Length (Pa)	0	1	3	6	9	14	19	24	31	39	47	56	66	77	88
Equivalent additional Straight Length due to bend (m)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9

Table B2: Data for 150mm VFLEX

Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	18	35	53	71	88	106	124	141	159	177	194	212	230	247	265
Friction Loss per Linear metre (Pa/m)	0	1	2	4	7	10	14	18	24	30	36	43	51	60	70
Friction Loss of R/D=4 Bend Only (Pa)	1	3	6	11	18	26	35	46	59	73	88	105	123	143	165
Friction Loss of Equivalent Straight Length (Pa)	0	1	3	5	8	12	17	22	29	36	44	53	62	73	84
Equivalent additional Straight Length due to bend (m)	1.8	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2
Friction Loss of R/D=1.5 Bend Only (Pa)	1	2	5	10	15	22	30	40	51	64	78	93	109	128	147
Friction Loss of Equivalent Straight Length (Pa)	0	1	1	3	4	6	9	11	14	18	22	27	31	37	42
Equivalent additional Straight Length due to bend (m)	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5

Table B3: Data for 150mm QFLEX

Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	18	35	53	71	88	106	124	141	159	177	194	212	230	247	265
Friction Loss per Linear metre (Pa/m)	0	1	3	6	9	13	17	22	28	34	41	49	58	67	76
Friction Loss of R/D=4 Bend Only (Pa)	1	5	10	19	29	42	58	76	97	120	146	174	205	238	274
Friction Loss of Equivalent Straight Length (Pa)	0	2	4	7	11	16	21	28	35	43	52	61	72	83	95
Equivalent additional Straight Length due to bend (m)	1.7	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.3
Friction Loss of R/D=1.5 Bend Only (Pa)	2	6	13	23	35	49	66	86	107	131	157	185	216	248	283
Friction Loss of Equivalent Straight Length (Pa)	0	1	2	4	6	9	12	15	19	23	28	33	39	45	52
Equivalent additional Straight Length due to bend (m)	3.7	3.5	3.4	3.4	3.3	3.3	3.2	3.2	3.2	3.1	3.1	3.1	3.1	3.1	3.0

Table B4: Data for 150mm UNILOK FR1 R1 (PLAIN)

Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	18	35	53	71	88	106	124	141	159	177	194	212	230	247	265
Friction Loss per Linear metre (Pa/m)	0	1	2	4	6	9	12	16	20	25	30	36	42	49	56
Friction Loss of R/D=4 Bend Only (Pa)	1	3	6	10	16	23	32	41	52	65	78	93	110	127	146
Friction Loss of Equivalent Straight Length (Pa)	0	1	3	4	7	10	14	18	23	28	34	40	47	55	63
Equivalent additional Straight Length due to bend (m)	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Friction Loss of R/D=1.5 Bend Only (Pa)	1	3	7	13	21	30	41	54	69	86	104	125	147	171	197
Friction Loss of Equivalent Straight Length (Pa)	0	0	1	2	3	4	6	8	10	12	15	18	21	24	28
Equivalent additional Straight Length due to bend (m)	2.5	2.6	2.7	2.8	2.8	2.8	2.9	2.9	2.9	2.9	3.0	3.0	3.0	3.0	3.0

Table B5: Data for 150mm UNILOK FR1 R1 AI (ACOUSTIC)

Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	18	35	53	71	88	106	124	141	159	177	194	212	230	247	265
Friction Loss per Linear metre (Pa/m)	1	2	5	8	13	19	25	33	41	50	60	72	84	96	110
Friction Loss of R/D=4 Bend Only (Pa)	2	10	22	38	59	85	116	151	191	235	284	338	396	459	527
Friction Loss of Equivalent Straight Length (Pa)	1	3	7	12	18	25	34	44	56	68	82	97	114	131	150
Equivalent additional Straight Length due to bend (m)	2.8	3.0	3.1	3.1	3.2	3.2	3.2	3.3	3.3	3.3	3.3	3.4	3.4	3.4	3.4
Friction Loss of R/D=1.5 Bend Only (Pa)	2	9	19	34	53	77	104	135	171	211	254	302	354	410	469
Friction Loss of Equivalent Straight Length (Pa)	0	2	4	7	11	15	21	27	34	42	50	59	69	80	92
Equivalent additional Straight Length due to bend (m)	3.0	3.1	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.4	3.4	3.4	3.4	3.4	3.4

Table B6: Data for 300mm TLP

Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	71	141	212	283	353	424	495	565	636	707	777	848	918	989	1060
Friction Loss per Linear metre (Pa/m)	0	1	3	5	7	10	14	18	23	29	35	41	48	56	64
Friction Loss of R/D=4 Bend Only (Pa)	1	5	13	23	36	53	73	96	122	152	184	221	260	303	350
Friction Loss of Equivalent Straight Length (Pa)	1	3	6	11	17	24	33	43	54	67	81	96	113	131	150
Equivalent additional Straight Length due to bend (m)	2.1	2.3	2.5	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.0	3.1	3.1
Friction Loss of R/D=1.5 Bend Only (Pa)	1	4	9	15	23	33	44	57	71	87	105	124	144	166	190
Friction Loss of Equivalent Straight Length (Pa)	0	1	3	5	8	11	15	20	25	30	37	44	51	60	68
Equivalent additional Straight Length due to bend (m)	2.5	2.3	2.2	2.2	2.1	2.1	2.0	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.9

Table B7: Data for 300 VFLEX

Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	71	141	212	283	353	424	495	565	636	707	777	848	918	989	1060
Friction Loss per Linear metre (Pa/m)	0	1	2	3	5	7	9	12	15	18	22	26	31	35	41
Friction Loss of R/D=4 Bend Only (Pa)	1	2	5	9	14	20	28	37	47	58	71	85	100	116	134
Friction Loss of Equivalent Straight Length (Pa)	0	2	4	6	10	14	19	25	31	39	47	56	65	75	87
Equivalent additional Straight Length due to bend (m)	0.5	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2
Friction Loss of R/D=1.5 Bend Only (Pa)	0	1	3	6	10	15	21	27	35	43	53	64	75	88	102
Friction Loss of Equivalent Straight Length (Pa)	0	1	2	3	5	6	9	11	14	18	22	26	30	35	40
Equivalent additional Straight Length due to bend (m)	0.8	1.0	1.1	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.5

Table B8: Data for 300mm Q FLEX

Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	71	141	212	283	353	424	495	565	636	707	777	848	918	989	1060
Friction Loss per Linear metre (Pa/m)	0	1	2	4	5	8	10	13	16	20	24	28	32	37	42
Friction Loss of R/D=4 Bend Only (Pa)	1	4	10	17	27	38	52	67	84	104	125	148	173	200	229
Friction Loss of Equivalent Straight Length (Pa)	1	2	4	7	11	16	21	27	33	41	49	57	67	77	87
Equivalent additional Straight Length due to bend (m)	2.4	2.6	2.7	2.8	2.9	3.0	3.1	3.1	3.2	3.2	3.2	3.3	3.3	3.3	3.4
Friction Loss of R/D=1.5 Bend Only (Pa)	1	4	9	15	24	34	47	61	78	96	116	138	162	188	216
Friction Loss of Equivalent Straight Length (Pa)	0	1	2	3	5	7	9	12	15	18	22	26	30	35	40
Equivalent additional Straight Length due to bend (m)	2.7	3.0	3.2	3.4	3.5	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2

Table B9: Data for 300mm UNILOK FR1 R1 (PLAIN)

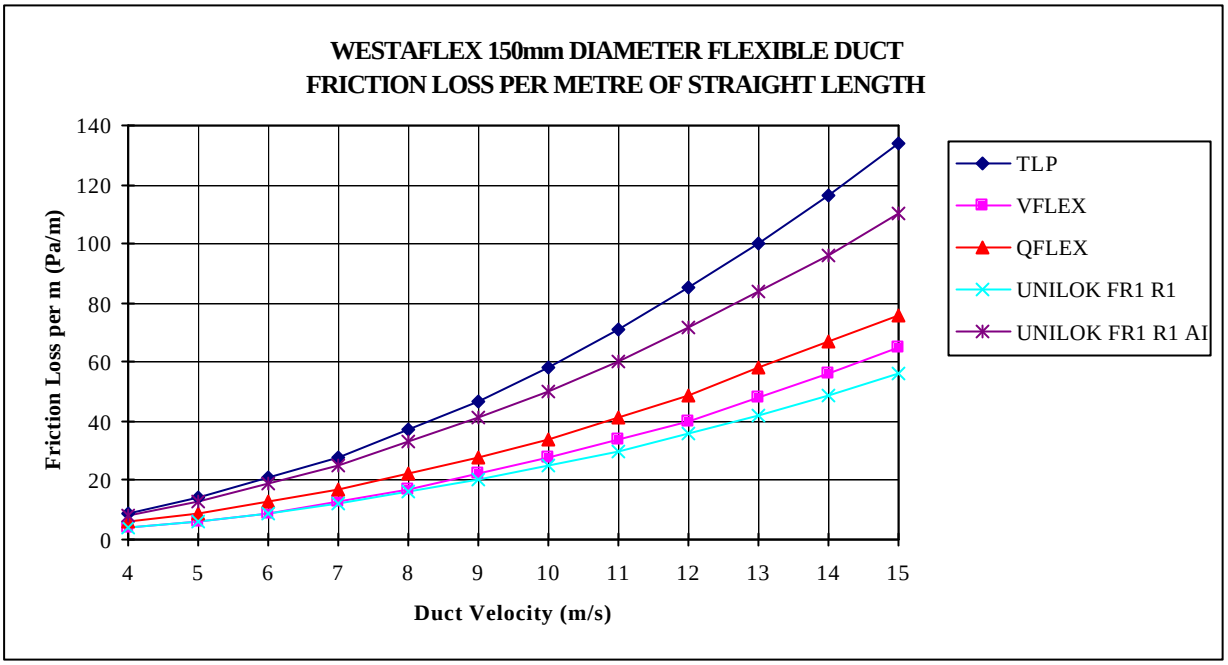
Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	71	141	212	283	353	424	495	565	636	707	777	848	918	989	1060
Friction Loss per Linear metre (Pa/m)	0	1	2	3	5	7	9	12	15	18	22	26	31	35	41
Friction Loss of R/D=4 Bend Only (Pa)	1	3	8	14	22	33	45	59	75	93	112	134	158	184	212
Friction Loss of Equivalent Straight Length (Pa)	0	2	4	7	11	15	21	27	34	42	50	59	69	80	92
Equivalent additional Straight Length due to bend (m)	1.7	2.0	2.1	2.3	2.4	2.5	2.6	2.6	2.7	2.8	2.8	2.9	2.9	2.9	3.0
Friction Loss of R/D=1.5 Bend Only (Pa)	1	3	8	13	21	31	42	55	69	86	104	124	146	169	195
Friction Loss of Equivalent Straight Length (Pa)	0	1	2	3	5	7	9	11	14	18	21	25	29	34	39
Equivalent additional Straight Length due to bend (m)	2.9	3.1	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.7	3.7	3.8	3.8	3.8	3.8

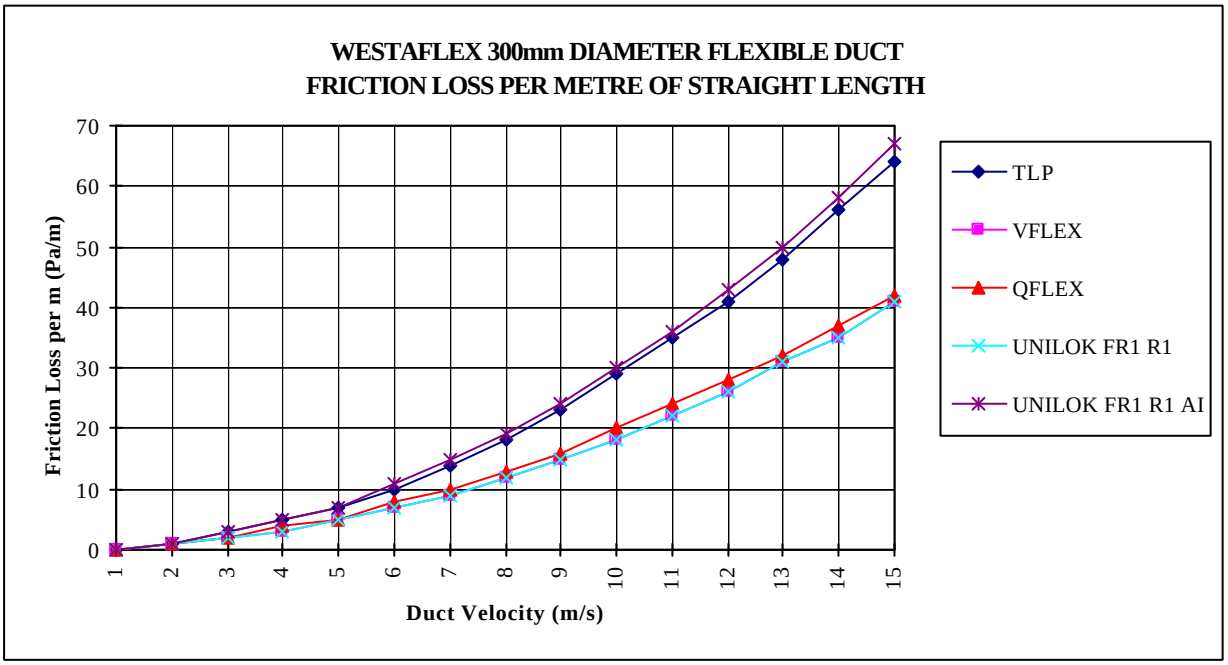
Table B10: Data for 300mm UNILOK FR1 R1 AI (ACOUSTIC)

Velocity m/s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flow Rate l/s	18	35	53	71	88	106	124	141	159	177	194	212	230	247	265
Friction Loss per Linear metre (Pa/m)	0	1	3	5	7	11	15	19	24	30	36	43	50	58	67
Friction Loss of R/D=4 Bend Only (Pa)	1	5	12	20	31	45	61	79	100	123	149	177	207	239	274
Friction Loss of Equivalent Straight Length (Pa)	1	3	6	11	17	24	33	43	54	67	81	97	114	132	152
Equivalent additional Straight Length due to bend (m)	2.3	2.2	2.1	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.8	1.8
Friction Loss of R/D=1.5 Bend Only (Pa)	1	5	10	18	28	40	54	71	89	110	132	157	183	212	242
Friction Loss of Equivalent Straight Length (Pa)	0	1	3	5	8	12	17	22	27	34	41	49	57	67	77
Equivalent additional Straight Length due to bend (m)	3.0	2.8	2.8	2.7	2.7	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5

APPENDIX C

PLOTS OF FRICTION LOSS OF STRAIGHT DUCT RUNS


WESTAFLEX 150mm DIAMETER FLEXIBLE DUCT
FRICTION LOSS PER METRE OF STRAIGHT LENGTH
Friction Loss per m (Pa/m)
0
20
40
60
80
100
120
140
4
5
6
7
8
9
10
11
12
13
14
15
Duct Velocity (m/s)
TLP
VFLEX
QFLEX
UNILOK FR1 R1
UNILOK FR1 R1 AI


WESTAFLEX 300mm DIAMETER FLEXIBLE DUCT
FRICTION LOSS PER METRE OF STRAIGHT LENGTH
Friction Loss per m (Pa/m)
0
10
20
30
40
50
60
70
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Duct Velocity (m/s)
TLP
VFLEX
QFLEX
UNILOK FR1 R1
UNILOK FR1 R1 AI