Refrigeration and Air conditioning Engineering.

3rd year – refrigeration and Air conditioning Course

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Duct design

Lecture -6-

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Duct design

An objective of duct system design is to provide a system that, within prescribed limits of velocities, noise intensity, and space available for ducts, efficiently transmits the required flow rate of air to each space while maintaining a proper balance between investment and operating cost. Commercial, industrial, and residential air duct system design must consider the followings:

(1) Space availability

(2) Space air diffusion

(3) Noise levels

(4) Duct leakage,

(5) Duct heat gains and losses

(6) Balancing

(7) Fire and smoke control

(8) Initial investment cost,

(9) System operating cost.

Head and Pressure

velocity pressure, calculated by Equation (1), is

$$p_v = \frac{1}{2}\rho\, C^2 \qquad \text{........(1)}$$

p_v**= Velocity pressure, Pa**

C = Fluid mean velocity, m/s

ρ **=Density air at standard conditions (1.2 kg/m3)**

Velocity is calculated by Equation (2).

$$C = \frac{V}{A} \qquad \text{.........(2)}$$

Where V = Air flow rate, m3/s

A = cross-sectional area of duct, m2

$$A = \frac{\pi}{4} D^2$$

Head and Pressure

Total Pressure: Total pressure is the sum of static pressure and velocity pressure:

$$p_t = p_s + p_v$$

p_t=**total pressure, Pa**

p_s=**static pressure, Pa**

p_v= **velocity pressure, Pa**

To determine the fan total pressure requirement for a system, use the following equation:

$$p_t = \sum_{iE,F_{up}} \Delta p_{t,i} + \sum_{iE,F_{dn}} \Delta p_{t,i}$$

For I = 1,2,…….$n_{up} + n_{dn}$

F_{up}**and** F_{dn} **= sets of duct sections upstream and downstream of a fan.**

FLUID RESISTANCE

Duct system losses The two types of losses are

(1) friction losses :Friction losses occur along the entire duct length.

(2) dynamic losses :result from flow disturbances caused by duct mounted equipment and fittings that change the airflow path's direction and/or area. These fittings include entries, exits, elbows, transitions, and junctions.

Friction Chart

The friction chart This chart is based on standard air flowing through round galvanized ducts with beaded slip couplings on 1220 mm centers, equivalent to an absolute roughness of 0.09 mm. Changes in barometric pressure, temperature, and humidity affect air density, air viscosity, and Reynolds number. No corrections to Figure 1 are needed for:

(1) duct materials with a medium smooth roughness factor,

(2) temperature variations in the order of ±15 K from 20°C,

(3) elevations to 500 m,

and (4) duct pressures from −5 to +5 kPa relative to the ambient pressure

Friction Chart

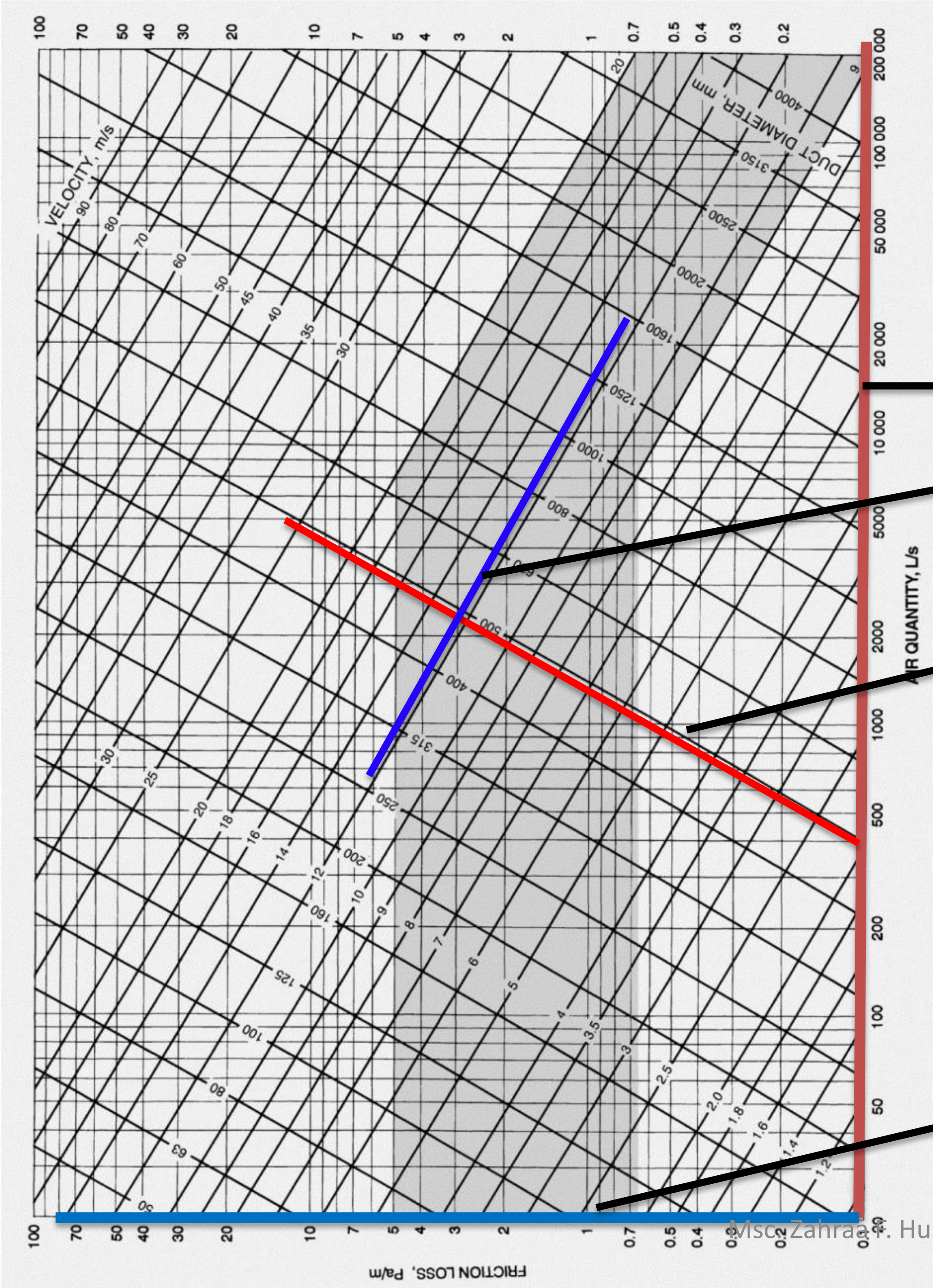


Fig. 9 Friction Chart for Round Duct (ρ = 1.20 kg/m³ and ε = 0.09 mm)

Air flow rate, (V) L/s

Velocity in the duct(m/s)

Duct diameter (mm)

ΔP = friction losses (pa/m)

Width (mm)

H (mm)

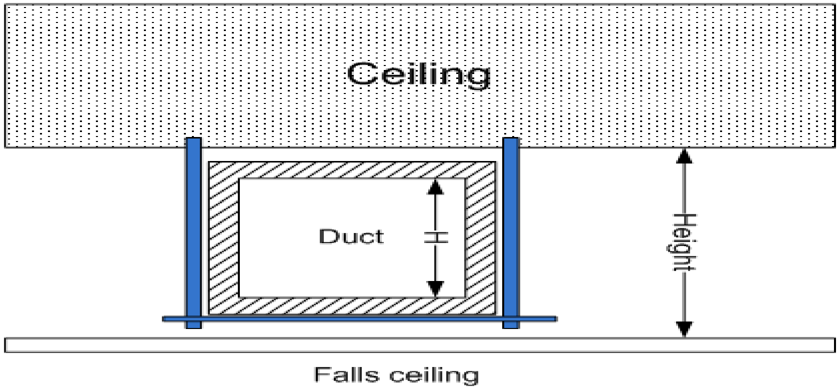
Duct diameter (mm)

Table 2 Circular Equivalents of Rectangular Duct for Equal Friction and Capacity[a]

Lgth Adj.[b]	Length of One Side of Rectangular Duct (a), mm																			
	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700	750	800	900
	Circular Duct Diameter, mm																			
100	109																			
125	122	137																		
150	133	150	164																	
175	143	161	177	191																
200	152	172	189	204	219															
225	161	181	200	216	232	246														
250	169	190	210	228	244	259	273													
275	176	199	220	238	256	272	287	301												
300	183	207	229	248	266	283	299	314	328											
350	195	222	245	267	286	305	322	339	354	383										
400	207	235	260	283	305	325	343	361	378	409	437									
450	217	247	274	299	321	343	363	382	400	433	464	492								
500	227	258	287	313	337	360	381	401	420	455	488	518	547							
550	236	269	299	326	352	375	398	419	439	477	511	543	573	601						
600	245	279	310	339	365	390	414	436	457	496	533	567	598	628	656					
650	253	289	321	351	378	404	429	452	474	515	553	589	622	653	683	711				
700	261	298	331	362	391	418	443	467	490	533	573	610	644	677	708	737	765			
750	268	306	341	373	402	430	457	482	506	550	592	630	666	700	732	763	792	820		
800	275	314	350	383	414	442	470	496	520	567	609	649	687	722	755	787	818	847	875	
900	289	330	367	402	435	465	494	522	548	597	643	686	726	763	799	833	866	897	927	984
1000	301	344	384	420	454	486	517	546	574	626	674	719	762	802	840	876	911	944	976	1037
1100	313	358	399	437	473	506	538	569	598	652	703	751	795	838	878	916	953	988	1022	1086
1200	324	370	413	453	490	525	558	590	620	677	731	780	827	872	914	954	993	1030	1066	1133
1300	334	382	426	468	506	543	577	610	642	701	757	808	857	904	948	990	1031	1069	1107	1177
1400	344	394	439	482	522	559	595	629	662	724	781	835	886	934	980	1024	1066	1107	1146	1220
1500	353	404	452	495	536	575	612	648	681	745	805	860	913	963	1011	1057	1100	1143	1183	1260
1600	362	415	463	508	551	591	629	665	700	766	827	885	939	991	1041	1088	1133	1177	1219	1298
1700	371	425	475	521	564	605	644	682	718	785	849	908	964	1018	1069	1118	1164	1209	1253	1335
1800	379	434	485	533	577	619	660	698	735	804	869	930	988	1043	1096	1146	1195	1241	1286	1371
1900	387	444	496	544	590	663	674	713	751	823	889	952	1012	1068	1122	1174	1224	1271	1318	1405
2000	395	453	506	555	602	646	688	728	767	840	908	973	1034	1092	1147	1200	1252	1301	1348	1438
2100	402	461	516	566	614	659	702	743	782	857	927	993	1055	1115	1172	1226	1279	1329	1378	1470
2200	410	470	525	577	625	671	715	757	797	874	945	1013	1076	1137	1195	1251	1305	1356	1406	1501
2300	417	478	534	587	636	683	728	771	812	890	963	1031	1097	1159	1218	1275	1330	1383	1434	1532
2400	424	486	543	597	647	695	740	784	826	905	980	1050	1116	1180	1241	1299	1355	1409	1461	1561
2500	430	494	552	606	658	706	753	797	840	920	996	1068	1136	1200	1262	1322	1379	1434	1488	1589
2600	437	501	560	616	668	717	764	810	853	935	1012	1085	1154	1220	1283	1344	1402	1459	1513	1617
2700	443	509	569	625	678	728	776	822	866	950	1028	1102	1173	1240	1304	1366	1425	1483	1538	1644
2800	450	516	577	634	688	738	787	834	879	964	1043	1119	1190	1259	1324	1387	1447	1506	1562	1670
2900	456	523	585	643	697	749	798	845	891	977	1058	1135	1208	1277	1344	1408	1469	1529	1586	1696

Table (2-1) Air velocity in duct system (m/s)

APPLICATION	CONTROLLING FACTOR NOISE GENERATION Main Duct	CONTROLLING FACTOR — DUCT FRICTION			
		Main Duels		Branch Duct	
		Supply	Return	Supply	Return
Residences	3.0	5.1	3.0	3.0	3.0
Apartments Hotel Bedrooms Hospital Bedrooms	5.1	7.6	6.6	6.1	5.1
Private Offices Directors Rooms Libraries	6.1	10.2	7.6	7.1	6.1
Theatres Auditoriums	4.1	6.6	5.6	5.1	4.1
General Offices High Class Restaurants High Class Stores Banks	7.6	10.2	7.6	8.1	6.1
Average Stores Cafeterias	8.5	10.2	7.6	8.1	6.1
Industrial	12.7	15.2	9.1	11.2	7.6



H= Height – 20 to 25 cm

For main Duct

H= Height (cm) - 20 to 25 (cm)

Example (1)

Find the dimension of the duct shown in Fig. 1, the maximum main duct height is 0.25 m.(**General Offices High Class)**

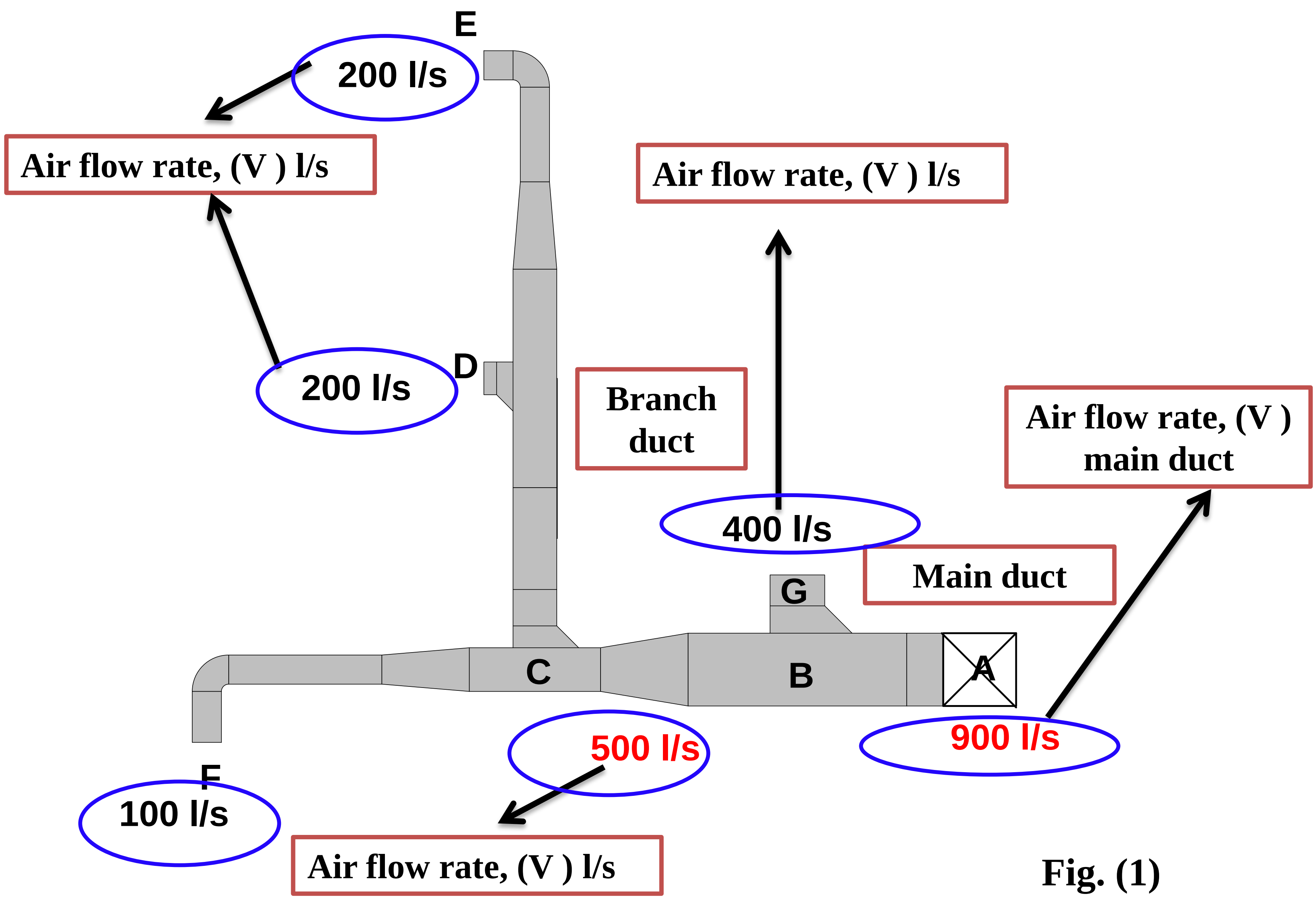

E
200 l/s
Air flow rate, (V) l/s
Air flow rate, (V) l/s
200 l/s
D
Branch duct
Air flow rate, (V) main duct
400 l/s
Main duct
G
C
B
A
500 l/s
900 l/s
F
100 l/s
Air flow rate, (V) l/s

Fig. (1)

- **Main duct section (1-2)**
- **V=C.A**
- **V=0.9 m^3/s**
- **C=7.6 m/s (T2-1)**
- **0.9=7.6×A**
- **A=0.11842 m^2**
- $A = \pi \frac{D^2}{4}$
- $0.11842 = \pi \frac{D^2}{4}$
- **D =0.388 m = 388 mm**

Table (2-1) Air velocity in duct system (m/s)

APPLICATION	CONTROLLING FACTOR NOISE GENERATION Main Duct	CONTROLLING FACTOR — DUCT FRICTION			
		Main Duels		Branch Duct	
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Apartments Hotel Bedrooms Hospital Bedrooms	5.1	7.6	6.6	6.1	5.1
Private Offices Directors Rooms Libraries	6.1	10.2	7.6	7.1	6.1
Theatres Auditoriums	4.1	6.6	5.6	5.1	4.1
General Offices High Class Restaurants High Class Stores Banks	7.6 C=7.6	10.2	7.6	8.1	6.1
Average Stores Cafeterias	8.5	10.2	7.6	8.1	6.1
Industrial	12.7	15.2	9.1	11.2	7.6

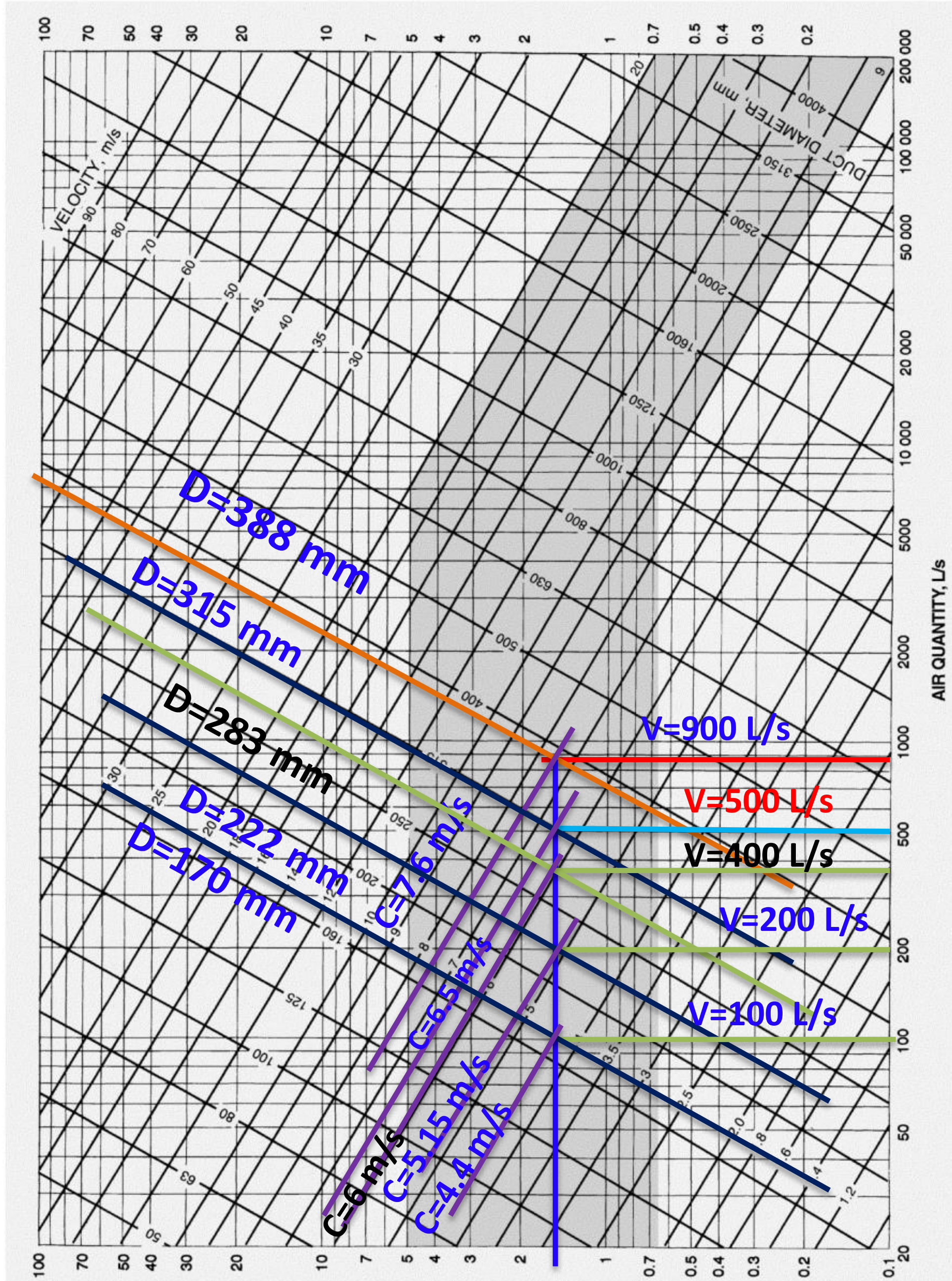

Fig. 9 Friction Chart for Round Duct ($\rho = 1.20\ kg/m^3$ and $\varepsilon = 0.09$ mm)

V=900 L/s

D=388 mm

Friction line

Friction loss= 1.68 Pa./m

W = 300 (mm)

W = 175 (mm)

W = 350 (mm)

W = 500 (mm)

W = 550 (mm)

H=150 (mm)

H=250 (mm)

Duct diameter=170 (mm)

Duct diameter=315 (mm)

Duct diameter=222 (mm)

Duct diameter=388 (mm)

Duct diameter=283 (mm)

Table 2 Circular Equivalents of Rectangular Duct for Equal Fri[illegible]

Length Adj.[b]	Length of One Side of Rectangular Duct (a), mm																			
	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700	750	800	900
	Circular Duct Diameter, mm																			
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450	217	247	274	299	321	343	363	382	400	433	464	492								
500	227	258	287	313	337	360	381	401	420	455	488	518	[illegible]							
550	236	269	299	326	352	375	398	419	439	477	511	543	573							
600	245	279	310	339	365	390	414	436	457	496	533	567	598	628	656					
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700	261	298	331	362	391	418	443	467	490	533	573	610	644	[illegible]	[illegible]	[illegible]	[illegible]			
750	268	306	341	373	402	430	457	482	506	550	592	630	666	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
800	275	314	350	383	414	442	470	496	520	567	609	649	687	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
900	289	330	367	402	435	465	494	522	548	597	643	686	726	763	799	833	866	897	927	984
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1400	344	394	439	482	522	559	595	629	662	724	781	835	[illegible]	934	980	1024	1066	1107	1146	1220
1500	353	404	452	495	536	575	612	648	681	745	805	860	913	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1600	362	415	463	508	551	591	629	665	700	766	827	885	939	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1700	371	425	475	521	564	605	644	682	718	785	849	908	964	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	379	434	485	533	577	619	660	698	735	804	869	930	988	1043	1096	1146	1195	1241	1286	1371
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2100	402	461	516	566	614	659	702	743	782	857	927	993	1055	1115	1172	1226	1279	1329	1378	1470
2200	410	470	525	577	625	671	715	757	797	874	945	1013	1076	1137	1195	1251	1305	1356	1406	1501
2300	417	478	534	587	636	683	728	771	812	890	963	1031	1097	1159	1218	1275	1330	1383	1434	1532
2400	424	486	543	597	647	695	740	784	826	905	980	1050	1116	1180	1241	1299	1355	1409	1461	1561
2500	430	494	552	606	658	706	753	797	840	920	996	1068	1136	1200	1262	1322	1379	1434	1488	1589
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2800	450	516	577	634	688	738	787	834	879	964	1043	1119	1190	1259	1324	1387	1447	1506	1562	1670
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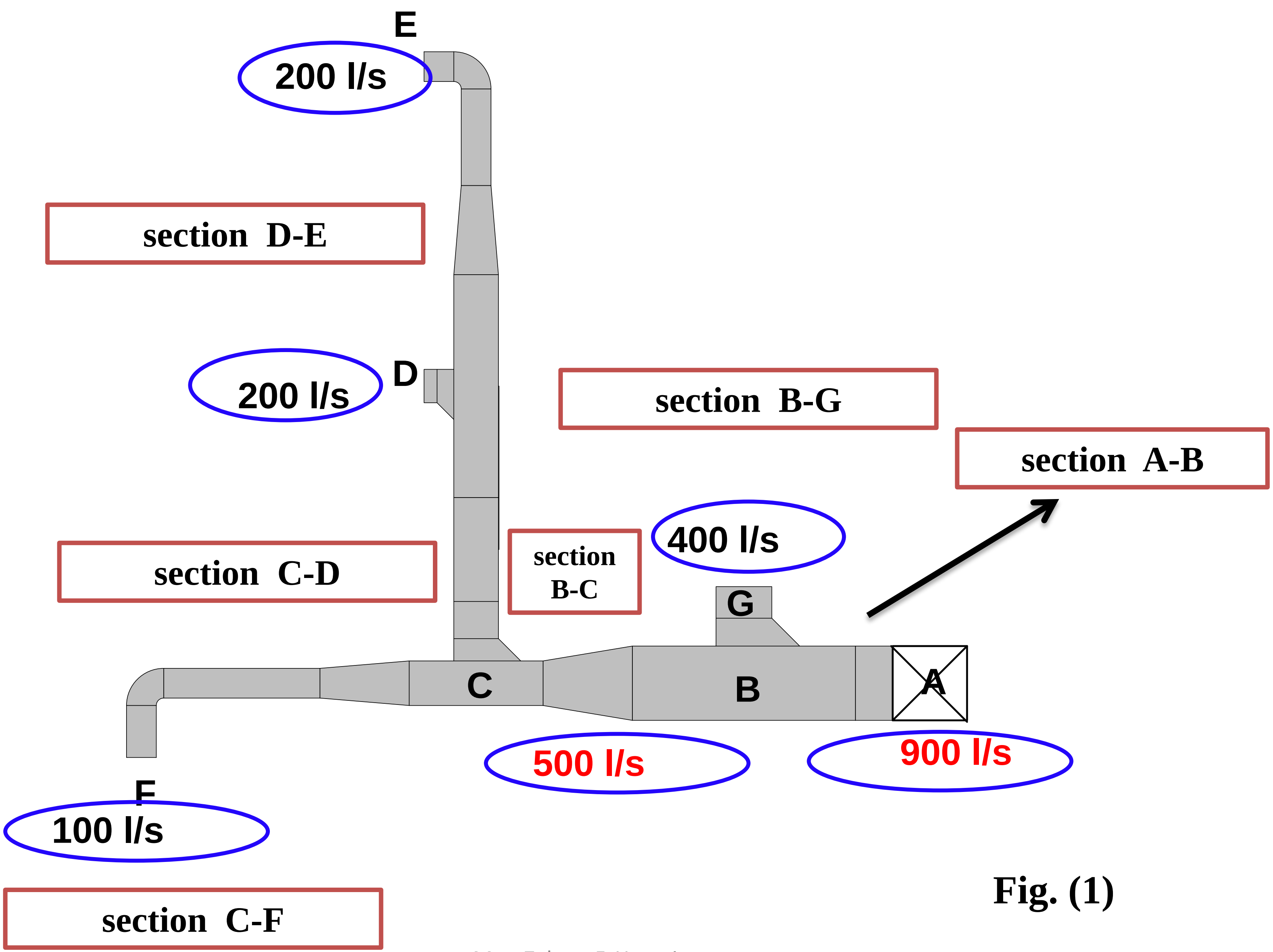
E
200 l/s
section D-E
D
200 l/s
section B-G
section A-B
section C-D
section
B-C
400 l/s
G
C
B
A
500 l/s
900 l/s
F
100 l/s
section C-F

Fig. (1)

Section	V (lit/s)	Deq. (mm)	C m/s	W (mm)	H (mm)
A-B	900	388	7.6	550	250
B-C	500	315	6.5	350	250
B-G	400	283	6	500	150
C-D	200	222	5.15	300	150
D-E	200	222	5.15	300	150
C-F	100	170	4.4	175	150