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ADVANTAGES OF TIGHT DUCT SYSTEMS

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Traditionally, ventilation and air conditioning ducts have been manufactured with rectangular cross sections. The rectangular duct can easily be adapted, e.g. to restricted ceiling voids and plant rooms, however, often at the cost of efficient airflow design and possible cost savings. A round duct system normally performs better and offers a more economical solution, which is the reason why it always pays to study and compare the ductwork design before selecting which type is to be used for a specific application.

The paper describes the need for better quality of ventilation ducts and describes different advantages round ducts have compared to rectangular ducts.

Circular ducts are more airtight than rectangular

It is of utmost importance that the air within a ventilation system is delivered to the designed outlet points and that leakage through the duct system is minimised.

The present Eurovent and the future CEN standards define three leakage classes:

A: the lowest class
Leakage factor: 1.320 litres/(s,m^2) at 400 Pa
(= 0.260 cfm/sqft at 8.4 lb./sqft)

B: the medium class
Leakage factor: 0.440 litres/(s,m^2) at 400 Pa
(= 0.087 cfm/sqft at 8.4 lb./sqft)

C: the highest class
Leakage factor: 0.15 litres/(s,m^2) at 400 Pa
(= 0.029 cfm/sqft at 8.4 lb./sqft)

Class C is thus three times tighter than Class B and nine times tighter than Class A, Figure 1.

Rectangular ducts of very high quality can as a maximum fulfil the requirements for tightness class B while round ducts installed with double rubber seals normally fulfils C. A recent study in France for a EU-SAVE project (France-Belgium-Sweden: 'Air distribution system leakage in Europe') showed that the (rectangular) ductwork did not even correspond to class A requirements.

These national differences depend on how stringent the tightness requirements are specified and controlled. Sweden could be used as an example of the development in this case. Since 1950 the

demands on HVAC installations are specified in 'HVAC AMA' ('General requirements for material and workmanship for HVAC installations' - with the author as project manager since 1976). Before 1960 only rectangular duct systems were installed. Then round ducts were introduced in Sweden in the early 1960's with some specialist companies starting batch production of round ducts and fittings. These were becoming more and popular with consultants and contractors during the following decade.

In 1972 tightness requirements were introduced as classes A and B corresponding to Eurovent standard 2/2. Following the changed energy situation after the first oil crisis 1972/73, AMA followed with the next class 'C' which could however only be required for round ducts as described above. The design of both rectangular and especially round ductwork has been largely improved. Rubber seals (for round ducts double rubber seals) have improved the tightness very much. Today it is time to raise the requirements once more, tightness class D, being three times tighter than class C, is being introduced in some countries and will be included in the next edition of 'AMA'.

But requirements have to be controlled to be of any value; AMA requires 10% of all round duct installations and 20% of all rectangular ducts to be tightness controlled (by the contractor under the supervision of the consultant). If the requirements of the prescribed tightness class is not fulfilled another equal portion of the installations are to be checked - and should it once more fail, all duct installations are to be tightness measured (on the cost of the contractor). It should be stated that today practically all installations are accepted with margin already the first time.

What are the advantages of round ductwork?

It is far simpler and more economical to connect various parts of a circular duct system than that of a rectangular:

- Connecting two circular spiral wound ducts only requires one fitting, Figure 2, whereas rectangular ducts are connected by use of a complete separate flanging system.
- The perimeter, that has to be sealed, is shorter on a circular duct:

  For the same free cross sectional area, a square duct has 13% longer perimeter than the circular one, for a rectangular duct with side ratio 1:2, the perimeter is 20% longer, 1:3 30%, 1:4 41% and 1:5 51% longer.

Ducts with a high degree of air tightness are increasingly in demand for many reasons:

- Air costs money and energy and it should be supplied and extracted where needed - not be permitted to leak out of or into the system uncontrolled. With rising energy prices, the cost for filtering, heating, cooling and distributing air is rising rapidly.
- They create a safer system. Good indoor air quality (IAQ) has to be guaranteed today. An increasing number of existing buildings are being classified as "Sick Buildings".

  One of the remedies to this is to increase the amount of fresh air intake. Harmful emissions are to be diluted by ventilation air to the extent needed to keep the concentrations at an acceptable level.

  Easy to clean and tight ducts will help to reduce this problem. With circular "airtight" ducts it is often easier and more economical to fulfil these increasingly stricter demands.

The installation cost is lower

- The overall cost of a duct system built with circular ducts is distinctly lower than one with rectangular ducts.
- The installation is simpler to carry out and the air tightness properties are better than when rectangular ducts are used.
- One circular duct is always installed at a lower overall cost than a rectangular of the same equivalent diameter, Figure 3.
- Using two circular ducts instead of one rectangular also results in a lower overall cost, Figure 4.

In some cases even several circular ducts can result in a lower cost when replacing one rectangular duct.

There are several reasons for the lower cost of the round duct system:

- It consists of a limited number of standardised components and sizes.
- Manufacturing of the ducts and fittings is highly automated and subject to advanced quality control.
- In some cases, the installation time for a circular duct system is only a third of that for a similar rectangular system.
- The cost for insulating is lower due to several reasons such as:
    1. The amount of insulating material is reduced due to the shorter perimeter of the circular duct compared with the rectangular one.
    2. Circular ducts are in some markets approved with thinner layers of outside fire insulation than the equivalent rectangular ducts.
    3. It is more accessible and therefore easier to lag.
- The in-situ cost (inclusive of transportation, packaging, waste, etc.,) is considerably lower for circular ducts than for rectangular with the same equivalent diameter.
- The number and dimensions of duct hangers is reduced. The space between two hangers is 2.5 m for a rectangular duct but 3.0 m for a circular one, thus reducing the required number of hangers and the cost and installation time needed by some 20%.
- Circular ducts often result in an improved control of the air flow distribution.

Easier to design

The round duct system is easier to design as it is using standard components with standard dimensions and compatibility. It is also easier and more accurate to calculate the pressure drop for a round system as all duct parts are well known and have been laboratory tested.

The delivery time is shorter

Circular ducts and fittings are stock items and can be delivered quickly which facilitates fast track building programmes. Due to standard sizes, straight ducts and duct components can be pre-manufactured and kept in stock normally resulting in delivery on same day as ordered.

Standardised ducts and components

Due to standardisation of sizes, a comprehensive range of fittings and ducts can be kept in stock. The duct diameters for the standard sizes follow a geometrical progression of cross sectional area with an approximate increase of the diameter of 25% over each step [following the series: (third root of 2:1)].

Nominal Internal Diameter, mm	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	(355)	**400**	(455)
Perimeter area per m length, m^2	0.198	0.251	0.314	0.393	0.502	0.628	0.785	0.990	1.115	1.257	1.413

Nominal Internal Diameter, mm	**500**	(560)	**630**	(710)	**800**	(900)	**1000**	(1120)	**1250**	(1400)	**1600**
Perimeter area per m length, m^2	1.571	1.760	1.979	2.229	2.512	2.826	3.142	3.517	3.927	4.400	5.030

With rectangular ducts you have to take precise measurements!
Rectangular ducts must always be manufactured tailor made for every individual installation, the variations are here practically infinite as both widths and heights vary, a bend can either turn around the flat or the high side, etc., the alternatives are thus too many to admit any batch production and automation of the manufacturing process.

The circular ducts can easily be cut to exact length on site and are thus much more flexible to alterations, mistakes, etc.
The rectangular ducts have to be made exactly to measure, any site alteration and adjustment is impossible and ducts of incorrect length have to be replaced. There is hence very little waste at the site, all parts of the round system can normally be used somewhere else in the building while a wrongly tailor-made rectangular duct has to be scrapped

Less space is often needed for the round duct system
The space required for installing a round duct is often less than that of a rectangular with similar pressure drop since rectangular ducts are joined by slip joints pushed onto the standing-seam joints, fitted on the ducts. Protrusions made by these flanges add to the space needed, Figure 5.

As these slip joints cover the duct width, they require an available space of the same order on either side of the duct, Figure 6.

Air flow measurements made the easy way
It is easier to measure the air flow passing through a circular than a rectangular duct. There are many flow measurement units especially designed for circular ducts available on the market, Figure 7.

With these accurate but inexpensive devices the ventilation systems can be equipped with fixed measuring units, a low cost method which enables regular check-ups or continuous monitoring.

A decreasing air flow has often been found to be the reason for a sound building turning "sick" - A fact that has been stressed on many air quality conferences during the last few years (and which has lead to a compulsory requirement in Sweden that all ventilation systems shall be inspected for function and airflow regularly in intervals between two and nine years. The interval depends on what consequences a failing function will have the users of the building. Hospitals and day nurseries belong e.g. to first group and apartment blocks to the latter group).

Also when making site measurements for control purposes, the circular ducts are easier to work with. When using the classic Prandtl-method the circular duct, regardless of size, has to be measured through two holes at right angles. The rectangular duct will have to be measured through several test holes, the larger the duct, the higher the number of holes for collecting the data needed to get the same measuring accuracy as for the circular duct, Figure 8.

Installation work, handling and transportation is simplified
The weight and bulk of a circular duct system is less than that of a rectangular, this influences the transportation and installation cost level and makes the system easier to install.

Round ducts can be transported with less unnecessary air - smaller diameter ducts can be pushed into larger ducts during transportation.

The installation time is much shorter for a round system which reduces the installation cost considerably. The duct length for a rectangular duct is maximised by the size of the steel sheet, 1.8 m is a normal length while a round duct can have any length as it is manufactured by a rolled steel band - 3 or 6 m are standard lengths. This means that are fewer time consuming (and leaking) duct connections on a round duct.

One individual is able to install circular duct systems up to diameter 200 single handed, whilst two people are always needed to install rectangular of any size.

For the same free cross sectional area the circular duct is not only less material consuming, due to its shorter perimeter and simpler connections, but the steel gauge can be reduced for the smaller and most frequently used duct dimensions due to the more rigid construction of a spiral wound circular duct.

The complete weight for a typical system comprising a normal combination of straight ducts, bends and diffusers, is between 30 and 40 % higher for a rectangular system than for a circular duct system.

Pressure drop is reduced

The pressure drop for a typical system comprising a normal combination of straight ducts, bends, and diffusers, is often lower for a circular duct system than for a rectangular.

This will lead to higher operation costs for the rectangular system; the required power from the fan is directly related to the pressure drop, and so also of course the consumed electric energy.

Inside cleaning of ducts

Some investigations of ventilation systems in buildings that have been classified as sick have shown that dust, fungus, etc., collected in supply and return air ducts have added to the emission load and thus to the sick building problem. The need for clean supply air ducts has been stressed on several international healthy building conferences. New building regulations in some countries, e.g. Sweden, also require regular inspection of the ductwork and internal cleaning when needed.

The cleaning methods (dry or wet) and cleaning tools (e.g. rotating brushes connected to heavy duty vacuum cleaners or hose connected spray nozzles for compressed air and detergents) used for internal duct cleaning are easier and cheaper to apply to circular than to rectangular ducts, due e.g. to the standard diameters of the circular ducts and the superior geometry.

Strength

Round ducts are normally made from a 137 mm wide steel strip which is seamed and formed into a perfect circular cross section. Round duct systems enjoy the strongest natural shape for withstanding pressure. Add to this a helical stiffener, 4 times the thickness of the tube in the form of the lockseam, results in a very rigid structure.

References:

1. The Best All 'Round Solutions - A designer's guide to the benefit of selecting a round ductwork system, Spiro International Group, Boesingen, Switzerland
2. VVS AMA 83 (in Swedish), J. V. Andersson (edit), Svensk Byggtjänst, Stockholm, Sweden

VENTILATION DUCTS – THE ROUND REVOLUTION

Background – a tremendous development from leaky primitive ducts to precision–made high quality tight ducts

Tightness – why?
- air should be supplied and extracted where needed – not leak out or in the system uncontrolled
- a safer system – SBS–reducing
- air costs money and energy

Tightness – how?
- precision–made ducts that always fit together
- longer ducts, less joints
- rubber gaskets
- quality assured by testing

Standard dimensions
- easier and more accurate to calculate pressure drop as all parts have been laboratory tested
- rigid ducts due to the spiral seam
- easier to design using standard components with standard dimensions and compatibility
- quick delivery
- easy to install, no slip joints
- less installation space needed, no slip joints
- no spillage – all parts can be used somewhere else in the building while a wrongly tailor–made rectangular duct has to be scrapped
- due to standard sizes, straight ducts and duct components can be pre–manufactured and kept in stock normally resulting in delivery on same day as ordered
- high flexibility – a round bend can be turned around 360° and fixed in any position – a rectangular bend has only two possibilities left–right or up–down

Aesthetics
- round ducts are more beautiful?
- a new way of architectural approach?
- do they have to be hidden?

Economy
- less material reduces first costs
- less weight reduces transportation and installation costs
- round ducts can be transported with less unnecessary air – smaller diameter ducts can be pushed into larger ducts during transportation
- shorter installation time reduces installation time

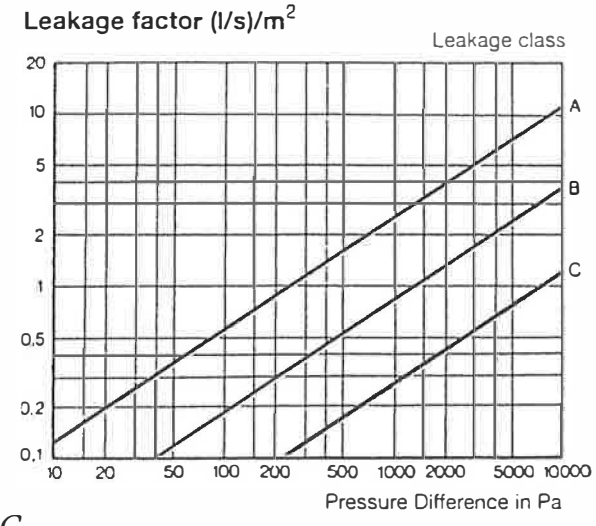


Figure 1 - *Tightness classes A, B, and C*

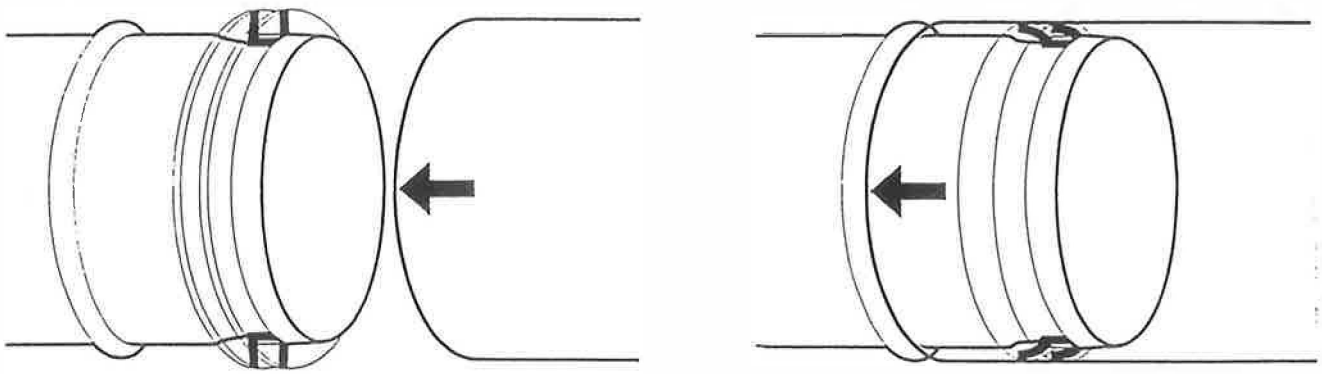


Figure 2 - *The double sealing gasket fits tightly against the tube*

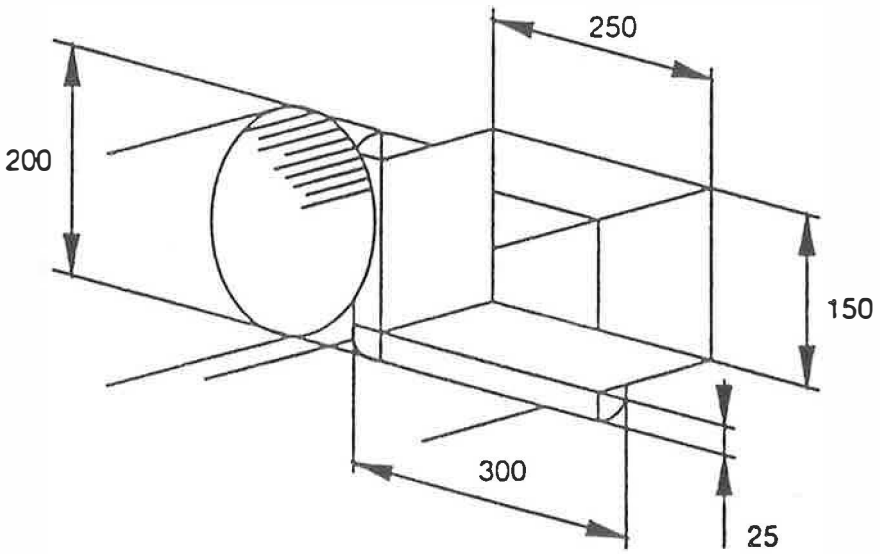


Figure 3 - *A rectangular duct, 250 x 150 mm can, without any increase in pressure drop, be replaced by a round duct with 250 mm diameter within the same space. The cost of round ducts are, in most cases, less than 50% of the cost for the rectangular duct.*

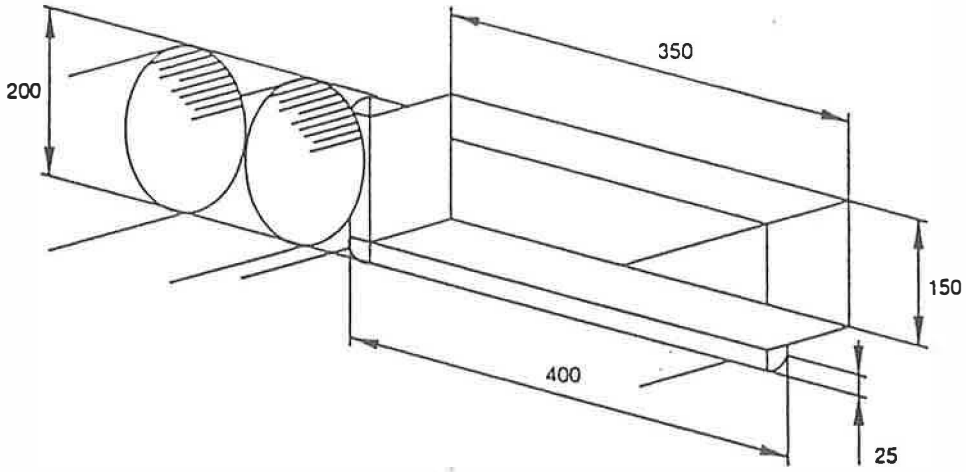
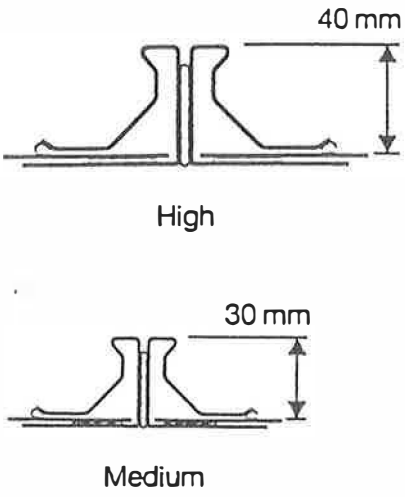


Figure 4 - *Flat rectangular ducts can often be replaced by several round ducts without any need for extra space.*



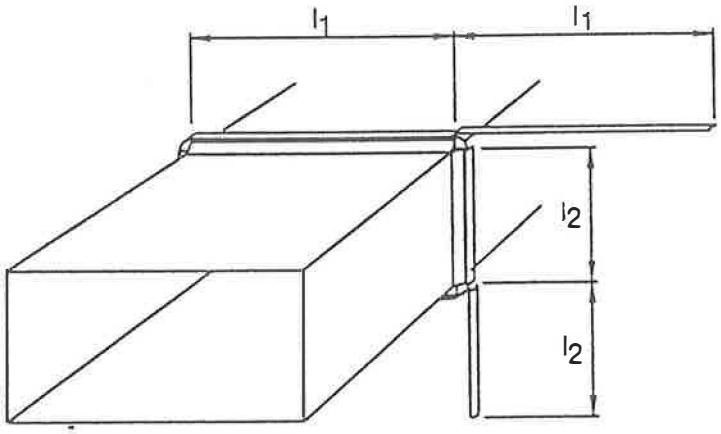


Figure 5 - *The space required for installing a rectangular duct is larger than the net area of the duct. The these flanges add considerably to the space needed.*

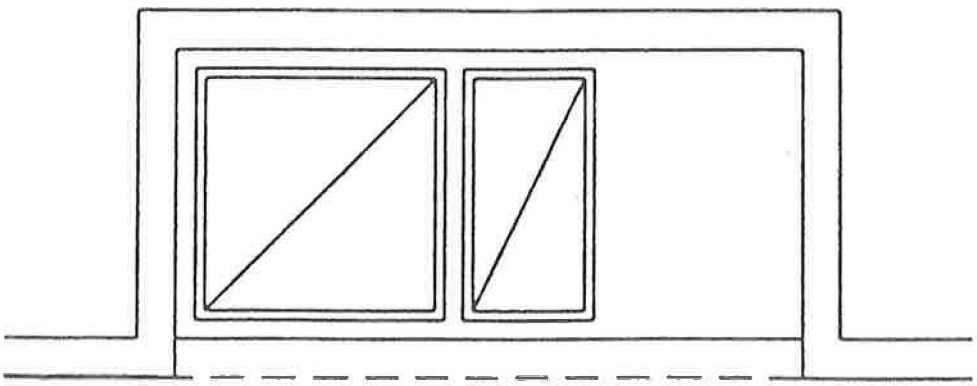


Figure 6 - *Even though it looks nice, the slip joints needed for the rectangular ducts make installations like this normally impossible while round ducts do not need any extra space for installation.*

Measuring Bend
MBU

Flow Measuring Unit
FMU

Blastgate Damper
SKMU

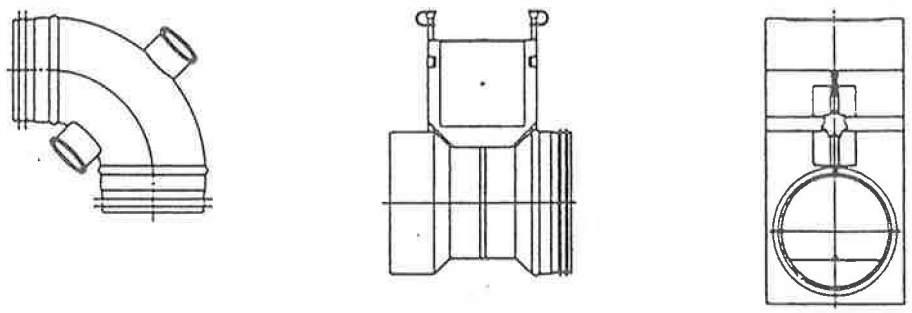


Figure 7 - *Air flow measurements made the easy way. There are several accurate and inexpensive devices to measure the airflow in the round duct system.*

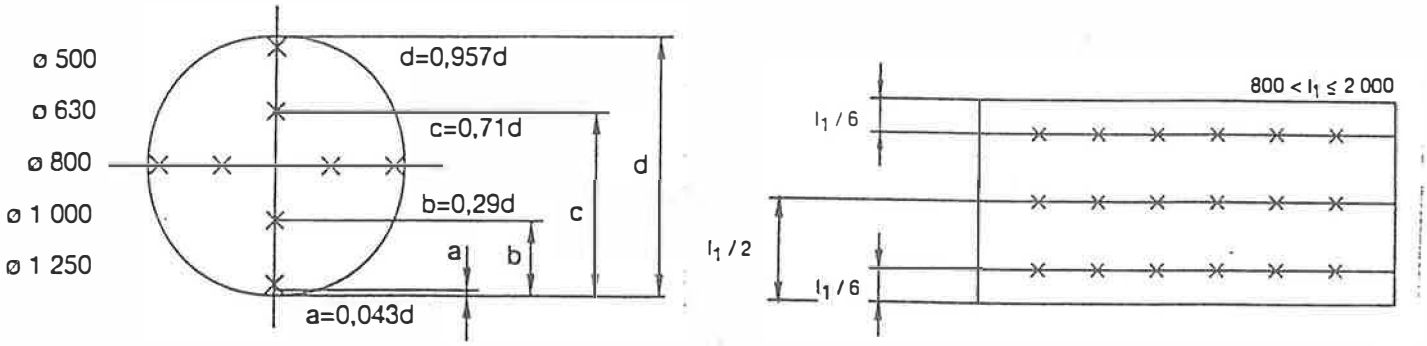


Figure 8 - *Air flow measurement with Prandtl-pipe is easier in a round duct than in a rectangular - 2 holes to drill instead of 6 for these duct dimensions.*

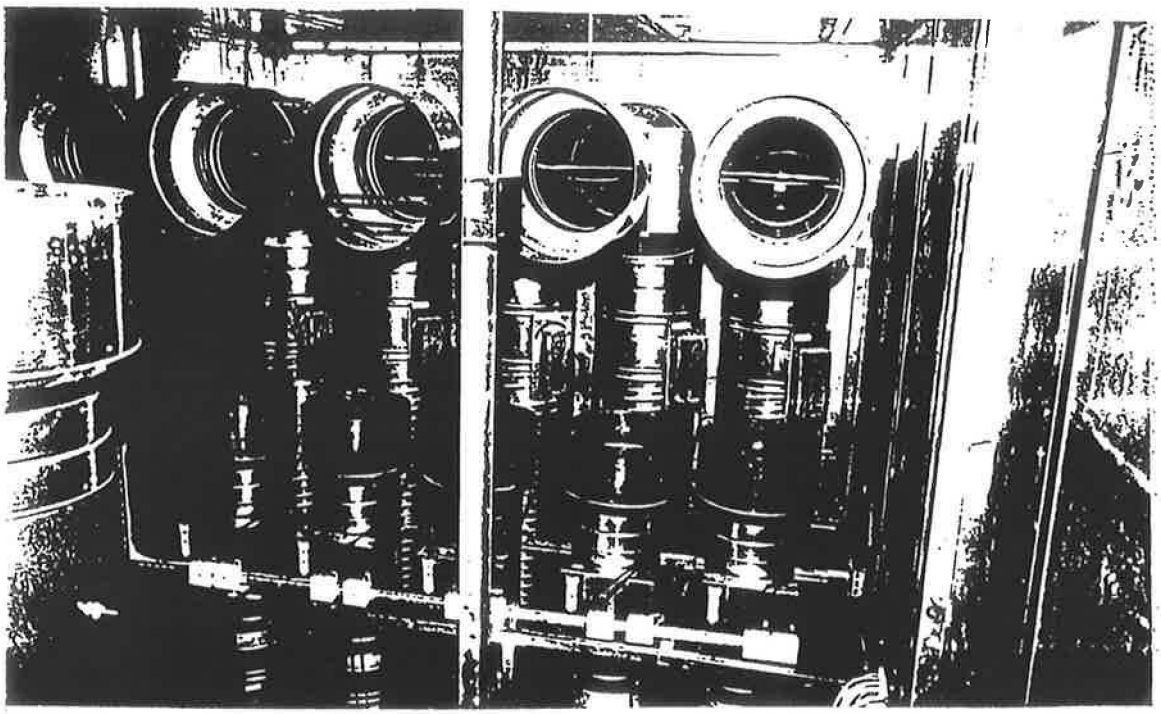


Figure 8 - *Round duct risers in a renovated office building in Stockholm.*

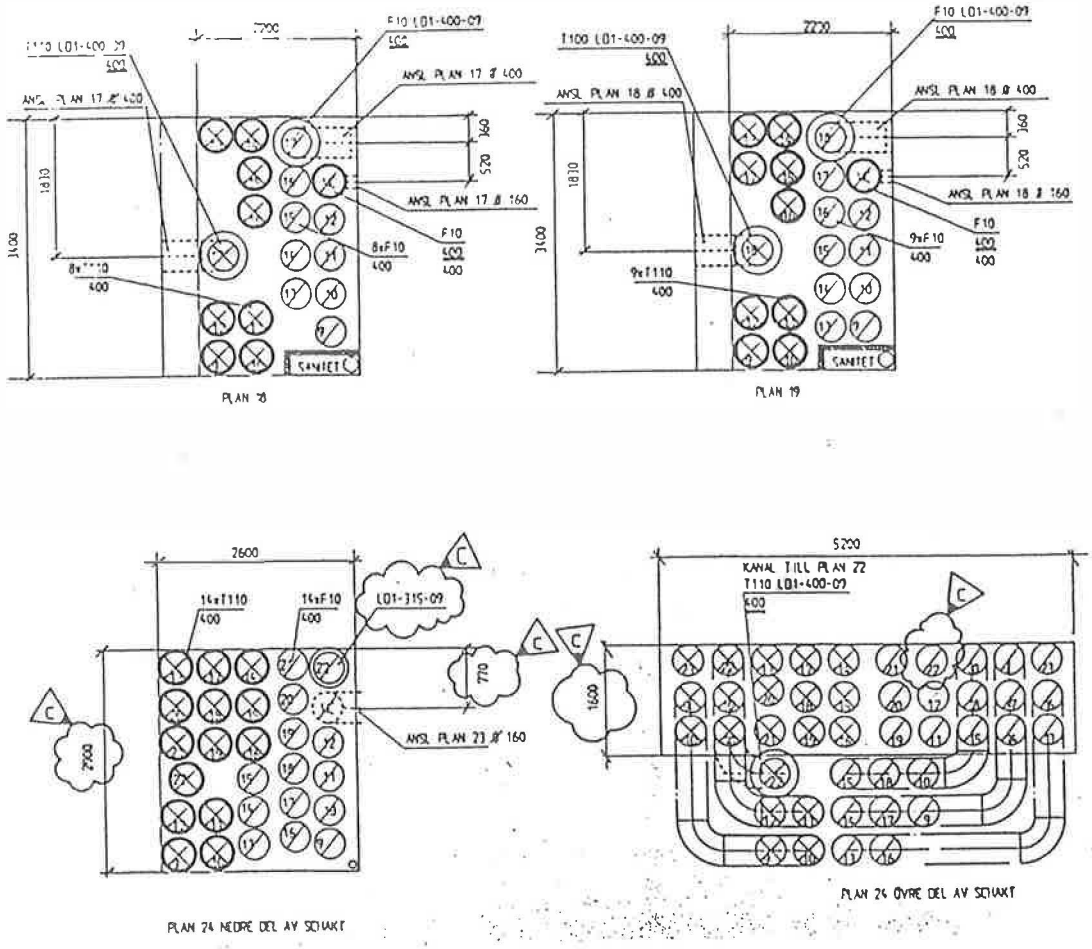


Figure 9 - *Drawing showing part of the duct installations*

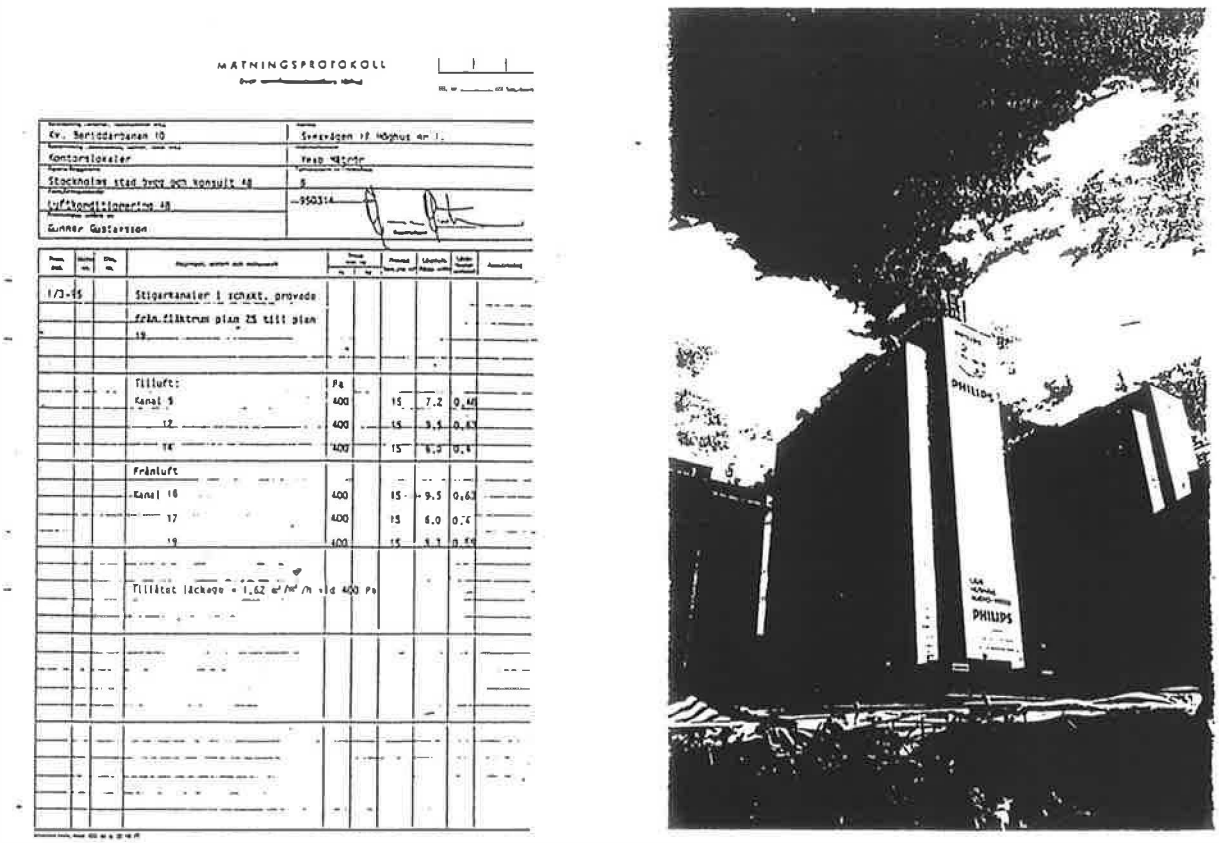


Figure 10 - *Protocol from the air tightness measurements. The required tightness is obtained.*