A GUIDE TO COMPRESSED AIR INSTALLATIONS

Thorite

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So often nowadays the sale of industrial equipment is treated as a ‘box moving’ exercise similar to domestic appliances where, say, if one needs a washing machine one knows it will do the household wash perfectly well whatever its make, colour or style, without having to consider the technical aspects.

The danger, however, in purchasing industrial plant this way is that what seemed a bargain at the time of purchase turns out to be a costly nightmare in operation because technical factors relating to the particular duty required were not studied beforehand.

We at the Thorite/Thomas Wright Group have always prided ourselves on our knowledge of the industry we represent, which gives us the ability to advise our customers on the correct equipment to match their particular requirements. Now we have put pen to paper to produce this guide, so that you can have reference to hand on the various factors involved in selecting the correct compressor plant to match your particular requirements.

At the end of the guide we have an example of how to put the information contained to a practical use.

We trust you will find it informative and helpful as a reference to use as and when your need arises.

ABBREVIATIONS USED

Litres/Minute (L/M).

Litres/second (L/s).

Cubic Feet/Minute (CFM)

Pneumatic control equipment manufacturers use cubic decimetres (dm^3). Don’t be confused, a cubic decimetre is equivalent to a Litre.

Contents

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Compressors

TYPES AND SELECTION

The ultimate aim when purchasing an air compressor is to acquire an adequate supply of compressed air at the lowest cost consistent with reliable service. As with all other forms of power transmission the installation of a compressed air system calls for capital investment with consequent operating and maintenance costs and, therefore, the information on which selection of plant is made should be as accurate as possible.

Lowest initial capital expenditure does not necessarily mean the best investment bargain.

The factors to be considered are dealt with below However, before detailing these it may be helpful to mention the types of compressors available. Air compressors fall into two general categories i.e. ‘positive displacement’ and ‘dynamic’.

POSITIVE DISPLACEMENT

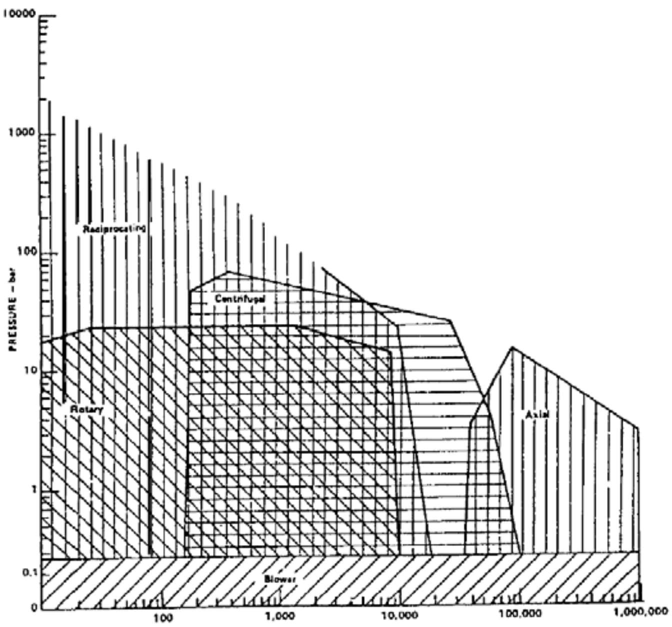
These compressors inhale air into a variable chamber which as it is reduced in size compresses the contained air and discharges it at a higher pressure.

Types of positive displacement compressor:

a) Reciprocating compressors. The compressing element, either a piston or diaphragm, has a reciprocating motion inside a cylindrical housing.

b) Helical and spiral lobe (screw) compressors have 2 rotary intermeshing rotors of helical form which displace and compress the air. They have high rotational speed and air discharged is free of pulsations.

c) Sliding vane compressors are rotary units in which axial vanes slide radially in a rotor which is revolving in an eccentric cylindrical housing. Discharged air is free of pulsations.



COMPRESSOR OPERATING RANGES

d) Two-impeller straight-lobed compressors and blowers have two straight mating but non-touching lobes which carry the air from intake port to discharge port. These are normally used for high flow/low pressure applications.

DYNAMIC COMPRESSORS

These are rotary continuous flow machines in which a rapidly rotating element accelerates the air passing through the element, converting the velocity head into pressure, partially in the rotating element and partially in stationary diffusers or blades.

Types of dynamic compressor:

a) Centrifugal compressors - acceleration of the air is obtained through the action of one or more rotating impellers, very high speed, free of pulsation.

b) Axial compressors - acceleration of the air is obtained through the action of a bladed rotor which is shrouded at the blade ends. Very high speed; high volume.

The majority of compressors used in the manufacturing industry are positive displacement types, either reciprocating, rotary vane or screw. Dynamic compressors are used where very high volumes of air are required.

THE BEST TYPE FOR THE APPLICATION

The first industrial use of reciprocating compressors can be traced back to 1860 and they have served industry very well since that date. However, despite their reliability and high efficiency (especially in the larger sizes) they do pose problems in respect of noise, vibration, installation costs and, due to the number of moving parts, overhaul when required can be lengthy and expensive.

The recent introduction of die cast aluminium components in small reciprocating compressors, 0.37 to 7.5 kW (0.5 to 10 H.P.), enables them to be manufactured in large quantities at low cost. This has opened up a very large market for D.I.Y. and small industrial users. These units are very reliable and give good monetary value.

Larger industrial users of compressed air now demand the low noise, reliability, ease of maintenance and installation offered by rotary vane and screw type compressors and these now have the major share of this market.

SIZE

The sizing of compressor plant should ideally be made on exact knowledge of consumption requirements of tools and average load factors. If this is underestimated the compressor will be too small and unable to maintain the required pressure.

Conversely, if requirements are over-estimated there may be excessive capital investment. However, it is safer to err on the high side, as in most instances the use of air will increase and take up surplus capacity. Always bear in mind future expansion.

This may be hard to predict accurately but it should not be too difficult to plan for 3 years and if, after such time, the compressor becomes overloaded it would then be financially sound to

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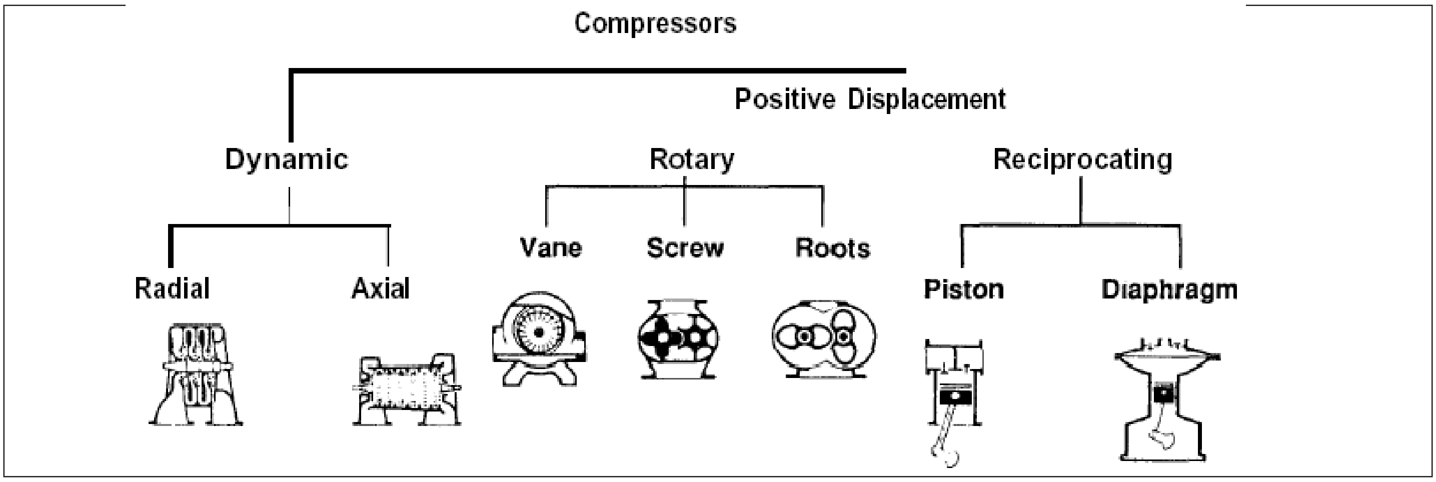


invest in additional or larger compressors.

Consideration should also be given to extra stand-by capacity by using two or more compressors This would allow production to continue in the event of failure on one compressor and servicing of compressors can be carried out in normal working time. Where air demand is variable it is also prudent to satisfy demand by using a number of compressors running in tandem, which can be controlled automatically so that only the minimum amount of energy is used to meet the demand at any one time. They can be set to cut ‘ON’ and ‘OFF’ in either sequential or cascade sequence.

OPERATING PRESSURE.

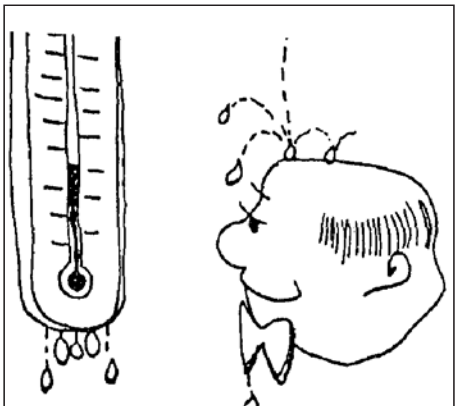
The quantity of air delivered by a compressor is relative to its working pressure. The higher the pressure the lower is the quantity delivered. It takes 1 kW of energy to compress 2.83 L/S (6 CFM) to a pressure of 7 bar (100 psi). It is therefore wasteful to compress air to a higher pressure than the optimum working pressure required. Most air-operated appliances work at 6 bar (88 psi) pressure and it is usual to operate the compressor at 7 bar (100 psi) to allow for regulation of the compressor and for transmission losses.

It is also wasteful to operate tools and appliances above their optimum working pressure as it increases the consumption without giving any increase in operating efficiency.

Where a specialised tool or appliance needs a higher pressure than that required for the rest of the factory it may be more economical to fit a high pressure compressor to deal solely with that particular requirement, especially if the volume required is small.

THE ENVIRONMENT

Compressors should be sited in a clean, cool, well ventilated environment with ample space around each unit to allow for cooling and maintenance purposes. Where large compressors are required it is wise to provide lifting facilities, not only for initial installation but also for future maintenance work to be carried out efficiently.

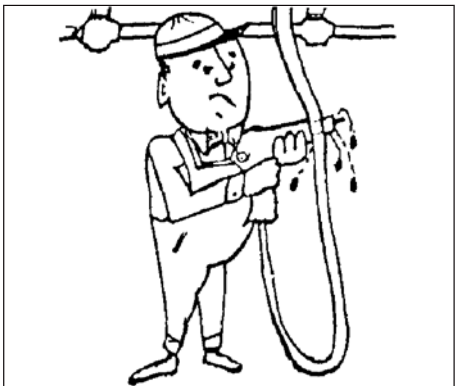


High Temperature = Loss of efficiency

Ventilation is important. Most small and medium sized compressors are now air cooled, and adequate ventilation, although essential, is often overlooked. Frequently louvre openings are fitted to compressor rooms to admit air, but no provision is made to extract the heated air. The result: there is no movement of the air and overheating occurs. A 4°C rise in ambient temperature will result in a 1% increase in energy to achieve equivalent output from the compressor.

Local noise restriction and maximum permissible noise level are further factors to be considered; the rotary vane and screw compressors are both much quieter in operation than their reciprocating contemporaries.

A CLEAN SYSTEM



Water & oil In airlines = breakdown = lost production

SAVES MONEY

The two worst enemies of a compressed air system are water and the oil carried over from the compressor. Poor quality air reduces the efficiency of air operated appliances and creates breakdowns which result in lost production.

Elimination of these two problems at source, before the air is fed into the distribution system, can pay large dividends.

ENERGY CONSERVATION.

This is a topic often discussed yet so

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TYPES AND SELECTION

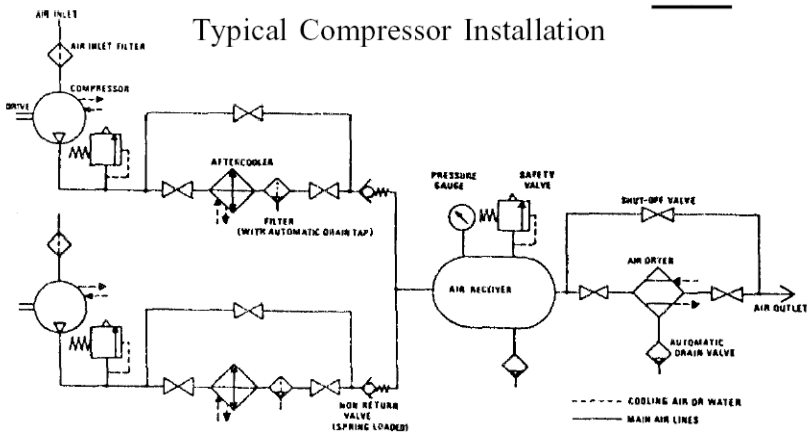
often neglected. What then can one do in regard to a compressed air system to save energy and stop one's hard earned profits going down the drain?

Regular preventative maintenance of compressor plant ensures maximum operating efficiency. Correct sizing of pipes, hoses and couplings and regular cleaning or renewal of filter elements, will all prevent pressure loss.

Earlier we mentioned that it takes 1 kW to produce 2.83L/s (6 CFM) at 7 bar (100 psi) so keep checking and correcting leaks. The equivalent of a 3 mm (1/8") dia. hole in a pipe containing 7 bar (100 psi) will lose you 3.36 kW (5 H.P.) of electricity.

Considerable savings can be made by fitting a pressure regulator to each air-operated appliance so that only the minimum pressure required to give operational efficiency is supplied.

Use of pressures above the minimum will increase consumption of the appliance without giving any increase in its efficiency.



Hole diameter	Air leakage at 7 bar	Power required by the compressor
mm	L/s	kW
0.4	0.19	0.06
1	1.18	0.37
1.6	2.8	0.97
1.6	2.8	0.97
3	10.95	3.36
6	49.1	15.0
10	122.0	37.0

The above table shows the volume of air (at 7 bar) lost through holes of various diameter, together with the resultant approximate power required to maintain such leakage.

HEAT RECLAMATION

The energy used by a compressor is all converted into heat the majority of which can be reclaimed. This is potentially the most rewarding area for energy savings and ideally should be considered when installing new compressors.

It is advisable, therefore, to seek advice from specialists when selecting compressor plant.

CHECKLIST 4

A summary of factors to consider when selecting compressor plant

1. **Volume of air required**
   Calculate total consumption of tools and appliances to be used, taking into consideration load factors, and add 25% to allow for future expansion. If in doubt ask for assistance.
2. **Working Pressure**
   Use minimum discharge pressure that will maintain acceptable working pressure at points of use. If just one or two particular appliances require a higher pressure than the rest of the factory, consider a separate high pressure compressor for this purpose.
3. **Load Splitting**
   In all installations thought should be given to having at least two compressors to allow for light load periods, energy saving and maintenance.
4. **Site Conditions**
   Must be cool, clean, well ventilated. Lifting facilities, space for servicing. Noise level and local restrictions on noise, ambient conditions - temperature, humidity and cleanliness of air, electrical supply voltage, phase frequency.
5. **Quality of air required**
   Type of dryer to give required dewpoint. Type of oil removal filters to give required quality of air.
6. **Initial Capital Investment**
   Lowest initial cost should not be the prime factor, as it may well prove to be the most expensive long term. Always take account of running, maintenance and repair costs and reliability.
7. **Servicing**
   Are spares and servicing facilities easily available.

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It is regrettable, but true, that a substantial proportion of responsible executives in small and medium sized businesses consider that the quality of compressed air is a matter of secondary importance. They believe that the only firms which need concern themselves about air quality are those which use large quantities of compressed air, those making use of sophisticated pneumatic applications. It is true that large companies go to considerable trouble in this field but they do it for one reason and one reason only. They know how much it will cost them if they don't.

The smaller compressed air user only differs in that he can frequently 'get by' with poor quality air and is unaware of the extra running costs that it involves. These extra running costs of course directly affect his profitability and competitiveness.

The truth of the matter, the undisputable truth, is that every user requires compressed air conditioning to a greater or lesser degree and responsible executives, unless they really know their subject, should always make a point of obtaining expert advice on the subject.

WATER VAPOUR

Atmospheric air always contains a considerable quantity of water vapour. The level of humidity may vary from location to location and from day to day, but water is always there (indeed, without it we would die) and whatever water vapour is in the atmosphere will be sucked in with the air at the compressor intake. When the air is compressed to 7 bar gauge (100 psig), each cubic metre of air at the intake is reduced in volume to one eighth of a cubic metre at the compressor discharge port. If the compression were to take place at constant temperature the reduced volume of air would no longer be able to retain all the water in vapour form and it would start to condense out as liquid water.

However, when air is compressed its temperature also rises and the hotter the air, the more water vapour it is able to contain, even at the reduced volume. Condensation does not therefore usually occur inside the compressor. In fact, manufacturers take stringent precautions to try and ensure that it does not, because of the obviously detrimental effect liquid water would have on the internal components of the compressor.

The problem therefore comes if the compressed air cools, which of course it does, in the pipelines after the compressor. As the air cools, water begins to condense out. The water then causes problems of corrosion, equipment inefficiency or malfunction and even (in the case of spray painting) product spoilage.

THE AFTERCOOLER

As much as 50 to 60% of the water vapour contained in the air can be condensed out by artificially cooling the air as soon as it leaves the compressor. This is the function of the aftercooler. Most of the new compressors, except the smallest, offered today by Thomas Wright/Thorite have their own aftercooler built in, but there are still a surprisingly high number of existing installations without an efficient aftercooler.

In any case a knowledge of how aftercoolers work and their limitations is important to an understanding of the operation of other compressed air conditioning components.

There are two basic types of aftercooler: air- and water-cooled.

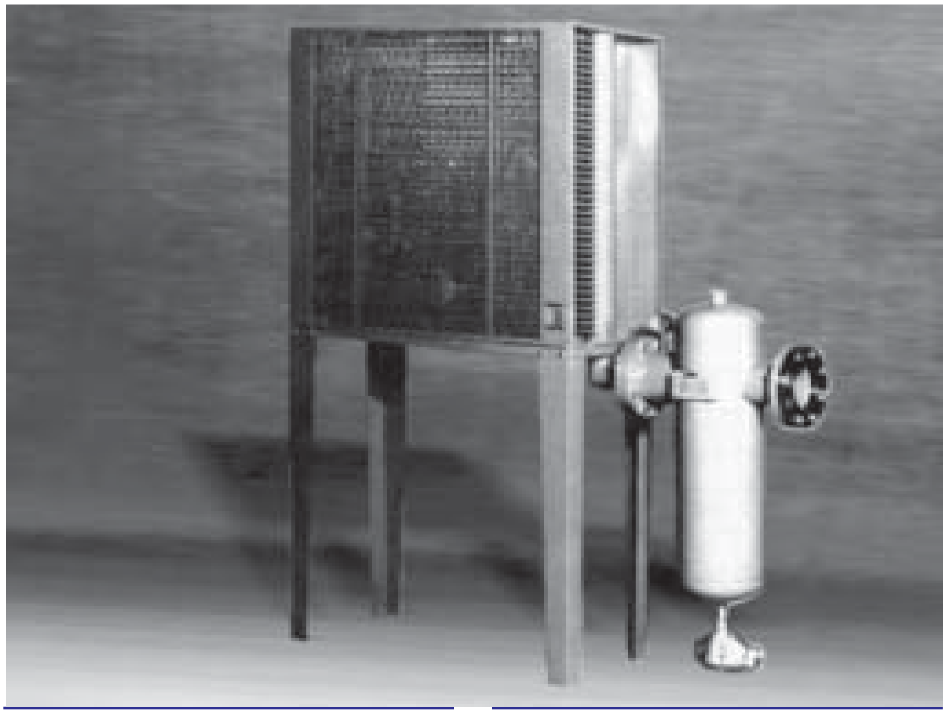
AIR COOLED AFTERCOOLERS

Most aftercoolers used in small systems are air-cooled so that no cooling water supply is required. The main components of an air-cooled aftercooler are the finned coil heat exchanger or 'radiator' through which the compressed air passes and a motor-driven fan which provides the ambient airstream across the coil.

Clearly the compressed air can only be cooled to a temperature somewhat above the temperature of the ambient air used to cool it. This temperature difference is usually between 5º to 15ºC depending upon the size and type of aftercooler, and how well it is matched to the application.

In order to select the right aftercooler for an installation, four main parameters must be considered:

- compressed air flow rate
- compressed air temperature at the inlet to the aftercooler



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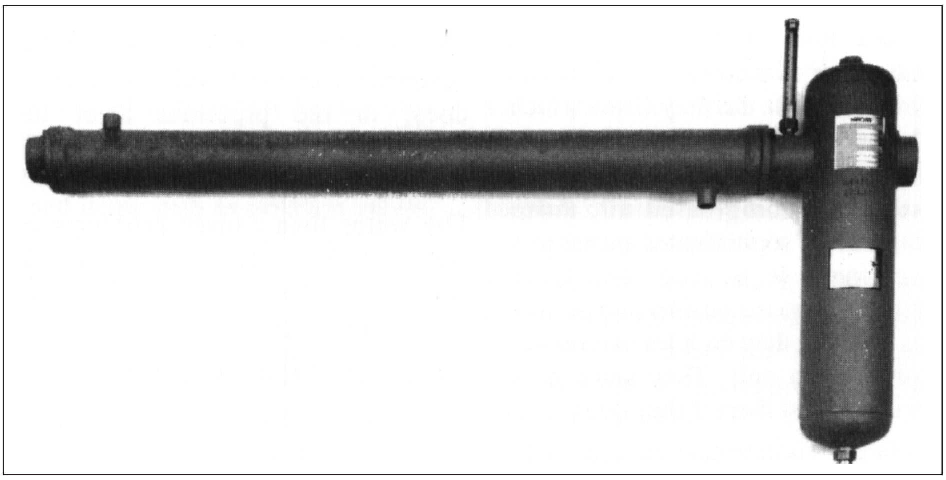
Compressed air conditioning

AFTERCOOLING

- working pressure
- the ambient conditions in the vicinity of the compressor and aftercooler.

The lower the compressed air temperature at the aftercooler outlet, the greater will be the quantity of water condensed out from the air. Here are two important tips in this respect:

1. Site the aftercooler where it has access to the coollest possible ambient air and make sure that the location is well ventilated



2. Brush out dirt and dust from between the fins of the aftercooler regularly with a soft brush and clean the tins thoroughly at least once a year.

Hiross air-cooled aftercoolers have a coil design incorporating copper tubes with aluminium fins which make them particularly efficient, compact and corrosion resistant. Standard units use electric motors to drive the cooling fan but Hiross can also offer versions with air-driven motors when required.

WATER-COOLED AFTERCOOLERS.

For some applications a water-cooled aftercooler may be more appropriate and, in some circumstances, it may even be possible to recover heat from the compressed air.

Thomas Wright/Thorite offer Hiross water-cooled aftercoolers which are of a shell-and-tube design. The compressed air flows through the tubes and is cooled by the water flowing across the outside of the tubes within the shell.

The secret of the high efficiency and compact dimensions of the Hiross aftercooler lies in the patented fin inserts which are used inside the copper tubes.

In order to select the right water-cooled aftercooler for an installation, the same parameters must be considered as for an air-cooled version, with additional information on the temperature and quantity of cooling water available.

Depending upon the quality of the cooling water there may be a tendency for scale to form on the outside of the tubes in the aftercooler. Appropriate measures in terms of water treatment and/or regular cleaning should be taken in order to prevent the build up of scale deposits which would otherwise reduce the efficiency of the aftercooler.

CONDENSATE SEPARATION

Causing water vapour to condense out of the compressed air is only part of the story. The condensate actually forms as a very fine mist which is suspended in the airstream and will still be carried downstream if some means is not employed of physically separating it from the air.

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In the previous section we examined the problem of water vapour in air and how compressed air can no longer retain all the water in vapour form when its temperature is reduced in an aftercooler so that condensation occurs.

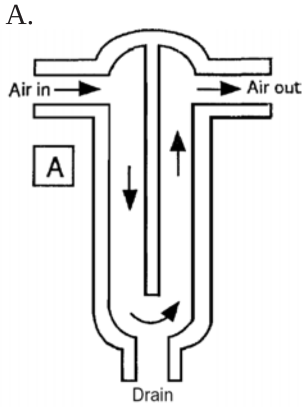
We looked at the different types of aftercooler available, selection criteria and gave some tips on getting the best performance from your aftercooler.

However, an aftercooler which is simply causing water vapour to condense out of the compressed air serves no useful purpose at all if the droplets of water are not separated from the airstream and drained out of the system.

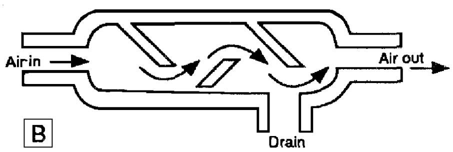
SEPARATION

When water condenses out of compressed air it does so as a very fine mist of microscopic droplets which is carried along in the airstream. Very few droplets are of sufficient weight simply to fall out from the airstream and it requires a change in direction of the airflow to start the process of separation.

A simple form of separator is shown in Figure A.



It consists of a small pressure vessel containing a baffle plate. The air entering the separator is forced to change direction as it reaches the baffle plate in order to get past. The heavier water droplets hit the baffle plate where they coalesce to form larger drops until the force of gravity is sufficient to cause them to run down the baffle and drip to the bottom. The efficiency of this type of separator can be increased by using a larger number of baffles as shown in figure B.

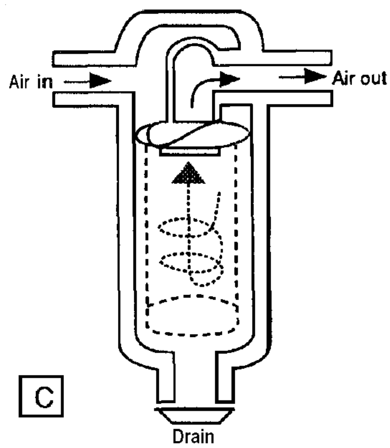


One immediate drawback of any separator of this type is obvious: in falling to the bottom, the water droplets have to traverse the airstream and some of the water is inevitably re-entrained in the compressed air. This type of separator is also of limited effectiveness in separating the finer droplets of water which tend to remain in the airstream rather than stopping on the baffles.

CENTRIFUGAL SEPARATORS

A much more efficient way of separating condensate from the airstream is through the vortex action of so-called centrifugal separation.

Figure C illustrates how this approach works. The air entering the separator flows across the vortex generator which effectively 'spins' the air around the inside of the vessel. This vortex action causes the water droplets to be flung to the inside walls of the separator where they coalesce and run down to the bottom. It is important to note that the greater proportion of finer droplets is also separated in this way.



It will also be noticed that the condensate that flows down the walls of the vessel does not have to cross the airstream in reaching the bottom and the risk of reentrainment is practically eliminated. The location of a horizontal baffle near the bottom of the separator creates a 'quiet zone' to prevent the air from stirring up the condensate at the bottom.

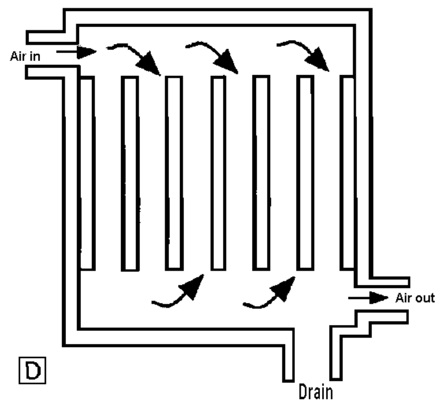
Hiross Condensate Separators offered by Thomas Wright/Thorite are of the centrifugal type. The ACS range covers flow rates up to 141L/s (300 cfm) and utilizes a cast aluminium construction, while for higher flow rates there are the NS models made from carbon steel.

A drawback with many separators is that their efficiency can decrease rapidly at higher and lower flow rates and pressures than the nominal conditions for which they are designed.

Computer-aided design techniques have enabled Hiross to overcome this problem and guarantee a separation efficiency between 95 and 99% over a wide range of operating conditions.

COMPRESSOR PACKAGES

Most rotary compressors today have built-in aftercoolers and it is common for the manufacturer to rely on the directional changes in airflow within the aftercooler to cause separation of the condensate as shown in figure D.



This is not very efficient and any installation incorporating such a compressor package would benefit from fitting a proper centrifugal separator at the outlet.

DOWNSTREAM SEPARATION

Of course it is not only in an aftercooler that moisture condenses out of the compressed air. When the air leaves the aftercooler, even if all the liquid water it contains is separated out, it is still saturated with water vapour. Since its temperature is several degrees above ambient, it will inevitably cool further in the distribution lines, causing more of the water vapour to condense out. Further centrifugal separators should therefore be installed near to the points of use of the air.

Ideally, though, a dryer should be installed in the first place immediately downstream of the aftercooler or air receiver, thereby eliminating any problems of condensation in the system.

CONDENSATE DRAINAGE

Once the condensate has collected in the bottom of the separator, or any other low point in the system for that matter, such as an air receiver or down-leg, it must be drained regularly. Otherwise the level will rise causing an excessive pressure drop and carry-over of water downstream.

A manual drain cock is not to be recommended in most cases because it will not usually be operated regularly or frequently enough. The answer is to install an automatic drain trap.

Automatic drain traps can be divided into two broad categories: electro-mechanical and mechanical.

ELECTROMECHANICAL AUTODRAINS

In electromechanical autodrains the valve is opened at preset intervals for a preset duration, either by means of a timer-operated solenoid or a motor driven cam.

The advantage of this type of valve is that being power operated it can have a large bore valve seat and is therefore usually good at handling quite viscous emulsions of condensate and oil.

However, it does need a power supply which can substantially increase installation costs and may make it rather inconvenient for downstream use. Since it operates on a time cycle and not when moisture has accumulated, it can either leave accumulated liquids in the system or waste air, depending on the setting.

Some autodrains of this type allow for adjustment of the setting but since the rate of moisture condensation can vary considerably over a day and over the year the settings will always be a compromise.

MECHANICAL AUTODRAINS

Nearly all mechanical autodrains use a float valve in one form or another. The immediately obvious advantage of this type is its simplicity of installation: it does not need a power supply. It also prevents wastage of air and accumulation of liquid because it maintains a nearly constant liquid level. As the level, and therefore the float, rises, the valve opens to discharge condensate, causing the level to fall and the valve to close again.

The discharge orifice is smaller than that in electromechanical types because of the mechanical force needed to open the valve. For this reason many float traps cannot readily cope with condensate that is contaminated with oil and dirt and are accordingly prone to blockage. This is especially true of drain traps designed for the comparatively clean condensate encountered in steam systems and such traps should never be used in a compressed air system.

A well designed float trap however, such as the Hiross SAC 120 (1/2") or SAC 100 (l"), can handle condensate with the degree of contamination found in most systems. Excessive contamination though is a symptom of a serious problem upstream and should be tackled at source.

Another important feature to look for in a drain trap is a manual vent which can be operated periodically to flush the trap and ensure that it is functioning correctly.

When an autodrain is first installed it is common for a lot of particles of dirt, rust, swarf etc. to find their way into it and it is therefore good practice to dismantle and clean it once or twice in the first few weeks of operation to prevent blockages.

Thereafter it may only need cleaning out once a year, depending upon the state of the system.

Under certain circumstances an automatic drain trap may fail to operate due to a phenomenon known as 'air binding'. This occurs when the air in the body of the trap is unable to pass back into the system past the condensate. This causes an increase in pressure in the trap to the point at which the condensate ceases flowing into it. The problem is solved by installing an internal balance nipple or an external pipe for pressure equalisation.

As always, it is worth seeking the kind of expert advice which can be provided by specialists such as Thomas Wright / Thorite Group.

AIR DRYING

The single most important step that the majority of compressed air users can take to improve the overall efficiency of their systems is the installation of a dryer. Why this should be so is dealt with in the next section.

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There is a popular misconception that the compressed air leaving an aftercooler is ‘dry’. Whilst it is true that an efficient aftercooler and separator may remove up to 60% of the water vapour contained in the air, there are two very important reasons why it cannot, by any stretch of the imagination, be considered dry:

1. the air leaving the aftercooler is 100% saturated so that any further temperature reduction will inevitably cause more water to condense out.

2. the temperature of the air leaving the aftercooler is likely to be between 25º and 35ºC and certainly above the surrounding ambient temperature.

The temperature of the compressed air will therefore fall as it flows through the distribution system, causing further condensation inside pipes, tools, instruments and other air-operated equipment.

To take care of this difficulty, and all the extra running costs it causes, a dryer is needed to provide compressed air with the right ‘dewpoint’.

DEWPOINT

What is dewpoint? The quantity of water vapour which air can hold depends upon its temperature and its pressure. If air is cooled at a constant pressure it will eventually reach a temperature at which it becomes saturated and any further reduction in temperature will cause moisture to condense as a liquid (as it does in an aftercooler). This saturation temperature is therefore a measure of the water vapour contained in the air and is referred to as its ‘dewpoint’.

REFRIGERATION DRYING

An obvious means of reducing the dewpoint of the air is by artificially cooling the air down to a low temperature before it passes into the distribution system. This is exactly what a refrigeration type dryer does. Refrigeration dryers normally cool the compressed air down to a temperature a little above freezing point, about 2º to 3°C because below this the condensate could freeze and block the system. The condensed water that this cooling produces is separated and drained so that the air leaving the dryer has a dewpoint of 3°C.

In the vast majority of industrial applications, the air temperature within the distribution lines is never likely to drop below this value; accordingly, no further condensation will occur and the whole system will stay dry. In fact most refrigeration dryers, except the smallest, also employ an air-to-air heat exchanger where the cold dry outgoing air pre-cools the warm saturated air entering the dryer. Provided that the condensed water has been effectively separated from the air in the dryer, reheating does not affect the dewpoint of the compressed air which remains at 3°C.

Employing the air-to-air heat exchanger reduces the amount of refrigeration capacity required and hence also reduces the energy consumption of the dryer.

Refrigeration dryers fall into two categories; thermal mass and direct expansion. The difference between the two types of refrigeration dryer is in the application of the cooling effect.

i) Thermal mass refrigeration dryer

A conventional refrigeration circuit is used to reduce the temperature of a vessel containing a thermal mass (e.g. a water/antifreeze mixture, brine, aluminium granules, etc.) to approximately 0°C.

Compressed air is then cooled by passing it through a coil immersed in the thermal mass in order to achieve the design pressure dewpoint. Within the thermal mass, the condensed water vapour is separated from the air stream and rejected to drain.

Obviously, in order to give the correct pressure dewpoint, the dryer must always maintain the thermal mass at the correct temperature so this type of dryer must always be switched on some time before the air compressor is started, in order to bring the thermal mass down to the operating temperature.

Thermal mass dryers may or may not be fitted with an air-to-air heat exchanger.

ii) Direct expansion refrigeration dryer

This type of dryer employs the simplest most positive method of drying compressed air: by cooling it via direct heat exchange with refrigerant.

A direct expansion dryer usually employs two heat exchangers which can be either separate vessels or encapsulated in one module. Saturated air enters an air-to-air heat exchanger where it is partly cooled by heat exchange with cold outgoing air. The air then passes to the air-to-refrigerant heat exchanger, or evaporator, where,

HIROSS DXB

1, Compressor
2. Condenser
3. Motor-fan
4. Evaporator
5. Separator
6. Condensate drain
7. Expansion capillary
8. Filter - dryer
9. Hot gas valve
10. Air-to-air heat exchanger
11. Suction gas muffler
12. Fan pressure switch
13. Dewpoint gauge

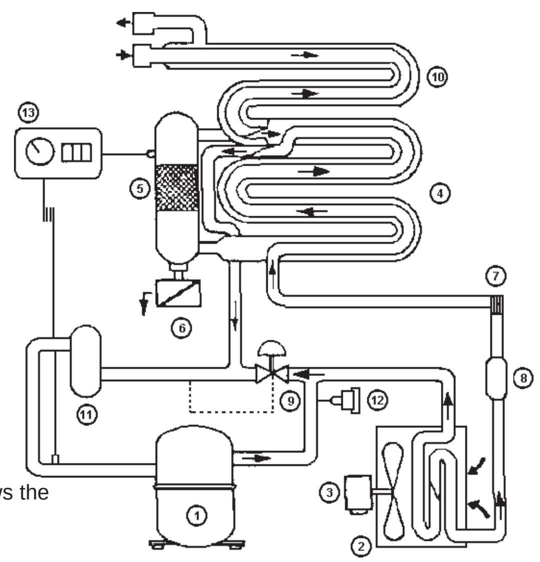


Diagram of the larger Polair range shows the air-to-air heat exchanger circuit.

by direct heat exchange with evaporating refrigerant, the compressed air is cooled to about 3°C.

The water vapour thus condensed is separated from the air stream and ejected via an automatic drain trap. The cold dry air then passes to the air-to-air heat exchanger where it is reheated by warm incoming air before leaving the dryer and entering the compressed air system.

Efficient heat exchanger design and effective pre-cooling/reheating not only reduces the cooling requirements from the evaporator (i.e. the running costs) but also delivers compressed air into the air main at near ambient temperatures thus preventing the formation of condensation on the outside of distribution pipework.

Of course, it is not enough for the dryer to ensure that it cools the air to a dewpoint of 3°C under steady full load conditions. The airflow and inlet temperature will always vary to a greater or lesser extent and the dryer must be capable of handling such a fluctuating load and still maintain a constant dewpoint. The Hiross dryers offered by Thomas Wright/Thorite all have a fully automatic system of control which ensures that the dewpoint remains constant from the full rated capacity right down to no-flow conditions.

Finally, it is important that the separator built in to the dryer is efficient, otherwise condensed water will be re-entrained into the compressed air.

SELECTION OF A REFRIGERATION TYPE DRYER

In order to select the right dryer for an installation four main parameters must be considered;

- compressed air flow rate
- air temperature at the inlet to dryer
- working pressure
- the ambient air temperature in the vicinity of the dryer

The compressed air flow rate may simply be that of the compressor for which the dryer is to be installed but not necessarily.

If the dryer is to be located downstream of the air receiver for example, the maximum flow rate through it may be lower or even higher than the rated output of the compressor. It is important to seek the advice of your Thomas Wright/Thorite representative in this respect.

The inlet temperature to the dryer should be as low as possible. At typical values of inlet temperature a difference of just 1°C can mean a difference of 4% in the thermal load on the dryer.

Make sure therefore that the aftercooler is efficient, adequately sized and well maintained.

The capacity of the dryer is also affected by the temperature of the ambient air around it. It should be sited where it has access to cool ambient air and the location should be well ventilated. The condenser fins of the dryer should be brushed and cleaned on a regular basis in the same way as for an airblast aftercooler.

LOWER DEWPOINT

While a dewpoint of 3°C is adequate for the vast majority of industrial applications there are some for which a lower dewpoint may be necessary, e.g.:

- handling systems for hygroscopic and some foods and beverages.
- instrumentation located out of doors.
- systems with very extensive external air mains subject to sub-zero temperature.
- assembly of some electronic components.
- special manufacturing processes requiring extra dry air.

Drying systems suitable for these applications, together with the benefits of drying, are covered in the next section.

The previous section discussed how water is removed from a compressed air system simply, effectively and economically by the installation of a refrigeration type air dryer. It did however mention a number of specialist applications which require compressed air at very low dewpoints. Such dewpoints cannot be achieved by cooling so a different type of dryer must be employed. There are two main types: deliquescent and desiccant.

DELIQUESCENT DRYERS

Deliquescent dryers will reduce the pressure dewpoint to approx. -16ºC: the actual figure achieved will depend upon the inlet air temperature and a number of other factors. They operate by passing air through a vessel filled with chemical pellets which gradually dissolve. The pellet stock requires regular servicing: the rate varies with conditions but it is not unusual for total replacement within a matter of months.

A deliquescent dryer should be fitted with an oil-removal filter immediately upstream because of the adverse effect of oil in any form on the pellets: a high quality after-filter, either integral or separate, is also essential because of the corrosive potential of the dissolved solution.

DESICCANT DRYERS

These units are able to provide compressed air at a pressure dewpoint as low as -40ºC. This dewpoint cannot be measured as a temperature: it is a degree of dryness that would have been achieved if the air temperature had actually been reduced to the stated level. Desiccant dryers employ granules of a special material which extract water vapour from compressed air by attraction and adhesion of gaseous and liquid molecules to their surfaces. This process is termed adsorption. The granules can then be 'regenerated' by extraction of the stored water. There are two basic types of desiccant dryers: 'heated' and 'heatless' so named because of the different processes they employ for regeneration of the desiccant.

With both designs, wet air enters at the inlet of the unit and is diverted to the selected adsorber where it is dried prior to leaving by way of a check valve. The adsorber is sized to dry a given air flow for a fixed period during which time the other adsorber is reactivated and pressurised.

HEATLESS DRYERS

Heatless dryers work on the principle of utilising the heat created by adsorption to assist in the regeneration of spent desiccant. Expanded dry air is passed through the spent adsorber and carries the desorbed moisture out of the system. Units of this type consist of two adsorbers connected in parallel through a main diversion valve on the inlet and opposing check valves on the outlet.

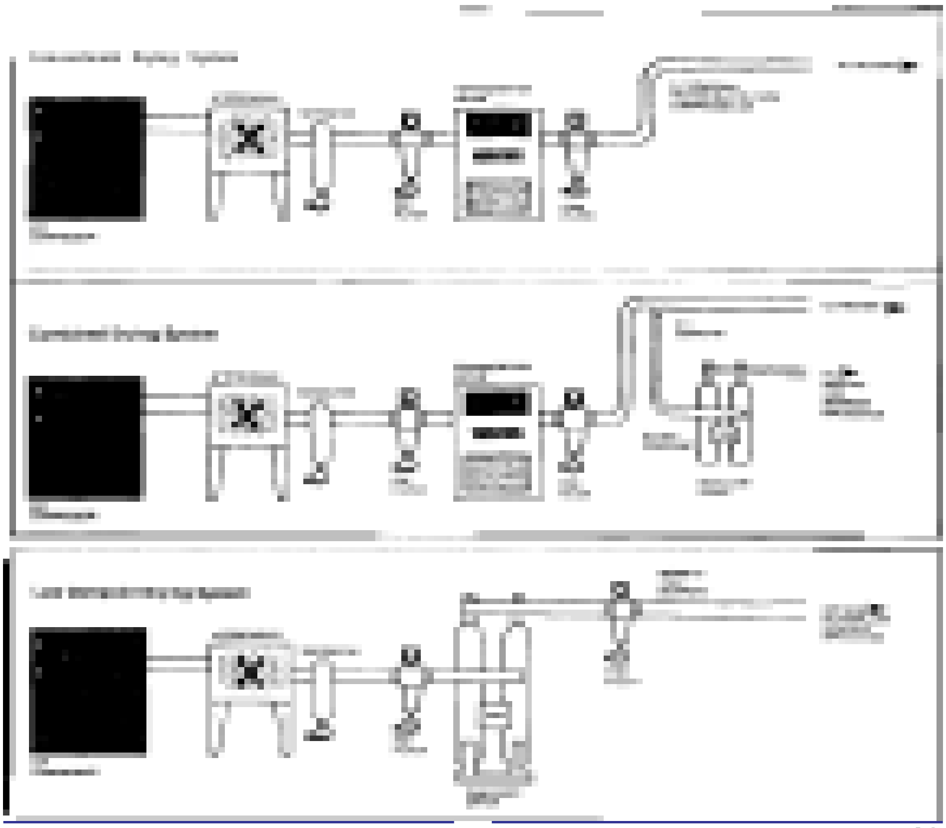
HEAT REACTIVATED DRYERS

These dryers operate on the internally heated plus dry purge air principle. Heat supplied to a 'wet' adsorber (by electric resistance heaters or steam coils) liberates the moisture from the pores of the desiccant and the dry air carries it to waste. Like heatless dryers these units also consist of two adsorbers connected in parallel through a main diversion valve. Approximately 3 - 5% of the total compressed air throughput is required to supplement the heat applied and regenerate the inactive adsorber. With both types of desiccant dryer, the inactive adsorber is pressurised prior to being put back on stream.

Running costs for both are considerably greater than for a refrigeration dryer of the same capacity. The granules themselves, furthermore, do not last for ever: replacement every 10,000 hours is advisable. It is important to bear these points in mind when selecting a dryer system.

ECONOMIC INSTALLATION OF A DRYER SYSTEM

As has already been explained, for the majority of applications, a pressure dewpoint of 3°C is more than adequate and, if lower dewpoints are required, they may not be necessary all year round. It is also often the case that, even if some processes or machines require very low dewpoint air, there are many more areas of the factory where a dewpoint of 3°C is sufficient.



DELIQUESCENT AND DESICCANT DRYERS

It is for circumstances such as these that a combined drying system should be considered.

COMBINED SYSTEM

In such a system, all the compressed air produced is dried at source using a refrigeration dryer. Areas and processes requiring very low dewpoint air, for whatever reason, can be satisfied by the installation of smaller 'point-of-use' desiccant dryers. These desiccant dryers, with their relatively high running costs, need only be used when ambient temperatures are low, or when processes requiring extra low dewpoint air are in operation.

At other times the plant is protected from all the problems associated with wet compressed air by the refrigeration dryer installed at source. This dryer with its much lower running costs not only yields a more cost-effective drying system but also takes the bulk of the load off the point-of-use desiccant dryers thus greatly reducing their running costs, in turn.

WHY DRY COMPRESSED AIR?

Water in compressed air causes rust, corrosion, wastage of air and many other problems even before the air is used. All these problems cost money. How many of the following problems do you accept?

- Rust
- Extra air cylinder maintenance
- Corrosion of air main
- Paint spraying blemishes
- Deliberate wastage of air
- Lubricator malfunction
- Extra air motor maintenance
- Corrosion of air receiver
- Accidental wastage of air
- Factory downtime
- Pneumatic instrument inaccuracy
- Emulsification of compressor oil
- Extra air system maintenance
- Product spoilage

Easy approx. conversion for Litres/second to cubic feet/minute. L/s x 2 + 10% or for greater accuracy L/s x 2 + 6%. 1 Bar equals 14.7 pounds/sq. inch.

One final problem remains: oil and dirt in the line. The oil in question is not the cool clean oil which is put into the system at the point-of-use to lubricate air tools, cylinders etc. but hot high pressure oil which is discharged into the distribution system by the air compressor. The latter is not suited to the lubrication of air tools.

We must consider two fundamental points:
- compressor oil carry-over must not be allowed into the air system.
- filtration is the only way to ensure its effective removal.

It must also be remembered that dirt, fumes and other impurities are present in the ambient air which is drawn into the air compressor, Only a limited quantity of the coarser particles can be removed by the intake filter and the rest are concentrated by the compression process. Also, pipework prior to the dryer will deposit rust scale, gasket material etc. into the air stream.

To ensure contaminant-free compressed air, filters must be used in conjunction with aftercoolers, separators and dryers. Each item has its own function to perform and when installed correctly each will complement the other.

FILTER ELEMENTS

Filter elements are manufactured in various forms to suit particular applications, be it a very coarse pre-filter or an activated carbon element to remove odours and vapours.

Prefilters - The removal of bulk liquids and particles. Generally these filters perform a ‘mechanical’ function i.e. the elements are manufactured from a porous material which ‘sieves’ particles from the air stream. These filters also protect subsequent finer filters.

Fine Filters - The removal of micro-scopic droplets of liquid, aerosols and dust.

The operation of these filters is based upon three different actions:

a) direct interception - larger particles collide with the filter media and are thereby removed from the airstream.

b) inertial impact - successive changes in direction of smaller particles as they encounter filter media fibres will lead to their progressive loss of energy until they finally adhere to a filter fibre.

c) Brownian diffusion - the random movement of smaller particles causing them to coalesce into larger ones due to electrostatic or intermolecular forces.

The coalesced liquid particles are pushed by the airflow towards the out-side of the element. An anti-re-entrainment and shock resistant barrier prevents them from being reabsorbed into the air stream and causes them to drain to the lower part of the element from where they are discharged from the filter casing.

Activated Carbon Filters - Odours and vapours are removed by a process of adsorption. The larger the surface area exposed to the air flow, the more efficient is this process. For this reason the element comprises a cartridge made of layers of finely ground and highly permeable activated carbon.

The Hiross Hyperfilter range includes the grades of filtration referred to above and covers flow rates from 15 cfm to over 6000 cfm and is stocked by all our branches.

FILTER SELECTION AND INSTALLATION

The efficiency and cost effectiveness of a filtration system depends upon the correct selection and installation of the individual components. The following suggestions are the result of many years experience in this field.

- When selecting a grade of filter, not only must the required air quality be known but also the existing air quality. This will allow for adequate prefiltration to be installed.

- Choose the filter corresponding to the maximum flow and minimum operating pressure expected at the point of filtration.

- When installing filters in existing pipelines choose a filter size which corresponds to the existing pipe size even if the filter is oversized. This will lead to minimal pressure drop and extended life.

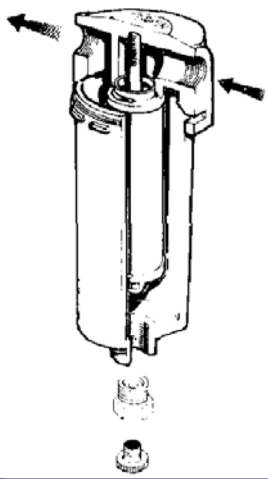
- Install filters at a point where the air is sufficiently cool - not only to maximise the element life but also to allow contaminants in vapour form to condense in order for the filter to act upon them.

- Provide enough space for the subsequent removal of the filter casing to allow ease of element replacement.

- Always install filters with a mechanism which indicates the air pressure drop across the element. This will indicate its working efficiency and ensure that the element is replaced on time, i.e. not too late - and not too soon!

- Always be aware of the different uses to which air from a single air compressor is put, e.g. a general purpose filter may be installed in a factory air main, but should some of that air be used for breathing purposes, or come into contact with food, then secondary point-of-use filtration must be installed.

The uses to which compressed air is put are many and varied but, in most cases, the single most effective step a compressed air user can take to reduce the running costs of his system is to install the right equipment to remove oil and water.



Compressed air systems

INSTALLATION

So far we have dealt with the various factors affecting the selection of air compressors, aftercoolers, dryers and filters, it therefore seems logical to end with some hints on how to transport the compressed air from the compressor plant to the final points of use.

Frequently the installation of the compressed air pipe system represents a large proportion of initial capital costs of a compressed air installation and therefore careful consideration should be given to ensuring that it is designed and installed correctly, in order to minimise high operational cost in the future. There are three main parameters to consider:

1. Lowest possible pressure loss between compressor plant and points of air consumption

2. Minimum leakage

3. Efficient separation of condensate throughout the system.

Loss of pressure through the pipe system results in either decrease of power to tools and appliances and inefficient operation, or having to run compressor plant at higher pressure than normal in order to obtain correct working pressures at tools and appliances thereby creating higher running cost of compressor plant.

To keep pressure loss to an acceptable minimum level the pipework should be of adequate internal dimensions and as direct as possible. Where restrictions to, or changes in direction of, air flow occur, such as through valves and fittings, the valves should be full flow type and sweep type bends and tee pieces should be used.

Allowance should be made for any future increase in compressor output and/or extensions to the pipe system. The cost of installing pipes and fittings of larger diameters than are strictly necessary at the outset is slight compared with the cost of changing to larger dimensions at a later date.

Leaks from a pipe system are continuous, whereas tools and appliances on average only operate 40 - 50% of the time. A leak, therefore, consumes twice the power of a tool with the same momentary consumption. A leak equivalent to a 3mm hole (l/S" dia.) in a pipe containing 7 bar (100 PSI) pressure will lose 3.36 kW (5 H.P) of electrical energy. Pipelines should therefore be accessible so that they can be maintained easily.

The main pipes should slope in the direction of air flow by a gradient of 1%. On long runs the pipe can revert to its original height by fitting a drain leg and 2 long sweep bends. Drain legs fitted with either manual or automatic drain valves should be fitted at all low parts of the pipe system.

Pipework should be adequately supported throughout its entire length and where materials with a high rate of thermal expansion are used allowance must be made for movement in order to relieve possible stresses occurring in the pipework. Main air lines may be sited at any level but it is generally found best to place them at high level as this practice affords easy access and good draining facilities. The speed of air flow through main line pipework should be less than 6 m/sec. and speed in final feed lines to tools and appliances that do not exceed 15 metres in length should be less than 15 m/sec.

These air flow rates can be assessed using the following formula:

Main Line piping.

$$V = \frac{1273 \times Q}{(P+1) \times D^2}$$

where

V = Flow velocity in Metres/Second
Q = Free air flow in Litres/Second
P = Air Pressure in Bar (Gauge)
D = Pipe Internal Diameter in mm.

Alternatively, if the free air flow is known the minimum diameter of the air

AIR FLOW THROUGH NOZZLES

NOTES:

1. The data right is based on 100% flow coefficient for a well rounded nozzle entrance; multiply these values by 0.96 where nozzles have sharp edged entry.
2. Values should be multiplied by 0.65 for approximate results with non-circular shapes.
3. Volume of air in L/s at 1 bar and 15°C
4. Pressure (bar) is gauge pressure.

Nozzle Dia. mm	Litres per second							
	2bar	3bar	4bar	5bar	6bar	7bar	8bar	10bar
0.1	0,004	0.006	0.008	0.009	0.011	0.012	0,014	0.017
0.2	0.018	0.024	0.032	0.036	0.044	0.048	0.056	0.068
0.3	0.041	0.054	0.063	0.0811	0.095	0.108	0.122	0.148
0.5	0.114	0.151	0.188	0.225	0.263	0.300	0.388	0.433
1.0	0.453	0.603	0.733	0.901	1.051	1.201	1.351	1.649
1.5	1.021	1.358	1.699	2.033	2.366	2.689	3.049	3.715
2.0	1.815	2.416	3.016	3.615	4.198	4.798	5.398	6.597
3.0	4.082	5.431	6.764	8.113	9.463	10.812	12.162	14.844
4.0	7.264	9.646	12.045	14.411	16.823	19.159	21.66	26.41
5.0	11.346	15.077	18.826	22.49	26.32	29.99	33.50	41.32
6.0	16.34	21.72	27.16	32.49	37.82	43.32	48.65	59.5

Easy approx. conversion for Litres/second to cubic feet/minute. L/s x 2 + 10% or for greater accuracy L/s x 2 + 6%. 1 Bar equals 14.7 pounds/sq. inch.

main to ensure velocities below 6m/sec can be found from the following

$$D = \frac{212 \times Q}{(P+1)}$$

Maximum permissible flow in branch feed lines may be found by using

$$Q = \frac{(P+1) \times D^2}{85}$$

There are two basic systems for compressed air mains:
1. A single line from supply to point(s) of usage
2. A closed loop circuit (ring main)

For installations where the point of supply and usage are relatively close, a single direct line will suffice. In this case the diameter of the pipe must be capable of carrying the maximum flow with no more than the maximum acceptable pressure drop. For installations with numerous take off points which are not relatively adjacent to each other a closed loop (ring main) system has advantages in that the velocity of air flow to any one point is reduced, since the air can converge on that point from two directions; also, by correct siting of isolating valves in the main line, it can be made possible to close down a section at a time for maintenance or emergency repair work whilst leaving the remainder of the system operational.

Feed lines to tools and machinery should be taken from the top of the main and sweep bends used to drop the line to a working height. An isolation valve should be fitted which is easily accessible. It is important that the final pressure to tool or appliance does not fall below minimum requirements. The feed line and items such as isolation valves, quick acting couplers and flexible hoses should therefore be of sufficient diameter to carry the required flow rate.

Piping materials can be of steel, copper, A.B.S. or thin-wall stainless steel. Copper and stainless steel are usually used for systems below 25 mm diameter or final drop feed lines,

Steel pipe, when used, should be to BS1387. This is available in black or galvanized form. The latter is recommended as it is less liable to corrode. It can be screwed to accept proprietary malleable fittings which should conform with BS 143 or BS 1256. For piping over 65mm bore, welded type fittings are recommended.

A.B.S. pipe suitable for use with compressed air is available. It is extremely tough and ductile and is self coloured light blue (the recommended colour for compressed air lines). It has good flow characteristics. As with all thermoplastics, A.B.S. has a limited temperature range. A.B.S. pipe must not be threaded.

A full range of fittings are available, joints being made by solvent fusion. Only jointing compound compatible with A.B.S. should be used. Most synthetic oils and a few mineral oils will degrade thermoplastics and elastomers and therefore oil suitability must be checked with pipework suppliers.

Experience has proved that planned maintenance of compressed air plant pays great dividends and likewise the same is equally true regarding the air distribution system.

Pressure gauges or test points at critical parts of the system and at final usage points will give easy indication of pressure losses and leak rates can be monitored at regular intervals by measuring the quantity of air delivered by the compressor to maintain normal pressure when all outlet points are turned off. In addition to this, regular inspection of couplings, hoses and pneumatically operated appliances should be made to locate and, if need be, correct leakage.

Compressed air is a valuable source of power, its efficient use will increase your profits. If you wish to check the efficiency of your existing system please contact our Technical Departments in Bradford or Leeds.

RECOMMENDED AIR FLOWS THROUGH MEDIUM WEIGHT BS1387 STEEL PIPE

Applied Gauge Pressure	NOMINAL STANDARD PIPE SIZE (NOMINAL BORE) – INCHES									
p.s.i.	1/8	1/4	318	1/2	3/4	1	1.1/4	1.1/Z	2	2.112	3
5	0.5	1.2	2.7	4.9	6.6	13	27	40	80	135	240
10	0.8	1.7	3.9	7.7	11.0	21	44	64	125	200	370
20	1.3	3.0	6.6	13.0	18.5	35	75	1 1 0	215	350	600
40	2.5	5.5	12.0	23.0	34.0	62	135	200	385	640	1100
60	3.5	8.0	18.0	34.0	50.0	93	195	290	560	900	1600
80	4.7	10.5	23.0	44.0	65.0	120	255	380	720	1200	2100
100	5.8	13.0	29.0	54.0	80.0	150	315	470	900	1450	2600
150	8.6	20.0	41.0	80.0	115.0	220	460	680	1350	2200	3900
200	11.5	26.0	58.0	108.0	155.0	290	620	910	1750	2800	5000
250	14.5	33.0	73.0	135.0	200.0	370	770	1150	2200	3500	6100

NOTES: The flow values are based on a Pressure drop (AP) as follows-

	PIPE SIZES
10% of applied pressure per 1 00ft. of pipe	I/8" - 112" incl.
5% of applied pressure per 100ft. of pipe	3/4" - 3" incl.

FLOWS GIVEN ARE IN S.C.F.M.
(TO CONVERT TO LITRES/SECOND, MULTIPLY BY 0.4717)

Compressed air systems

ASSESSMENT OF COMPRESSOR PLANT

EXAMPLE

In order to give a practical example of how to use the information contained in this guide let us consider a hypothetical, new, medium sized production factory and work through the factors that we need to consider in order to ascertain the compressed air plant requirements. The factory will be on continuous production cycle.

ASSESSING VOLUME REQUIRED PRODUCTION DEPT.

Two machines.

Refer to Cylinder Consumption Table 1
1 machine using 2 off 160mm bore cylinders with 75mm stroke operating at 2 times/minute.
160mm bore = 0.13 litres per mm stroke
Therefore 0.13 x 75mm stroke x 2 strokes/cycle =
19.75 x 2ops/minute x 2 off cylinders = 78L/M (1.3L/s).
1 machine using 4 off 100mm bore x 50mm stroke cylinders at 15 ops/minute
0.051 x 50 x 2 x 15 x 4 = 306 L/M (5.1 L/s).
Total Consumption Production Dept. = 6.4 L/s

ASSEMBLY SHOP

Refer to Tool Consumption Table 2

Qty	Item	Column 1	Col. 2	Col. 3	Total
2	Drills Medium	8 L/s	0.20	1.6 L/s	3.2 L/s
2	Drills Light	6 L/s	0.20	1.2 L/s	2.4 L/s
2	Imp. wrenches	23 L/s	0.10	2.3 L/s	4.6 L/s

Total Consumption Assembly Shop = 10.2 L/s

PREPARATION DEPT.

2	Orbital sanders	11.0 L/s	0.50	5.5 L/s	11.0 L/s

FINISHING DEPT.

2	Spray Guns	7 .0 L/s	0.50	3.5 L/s	7.0 L/s

GENERAL

3	Blow Guns	8.0 L/s	0.10	0.8 L/s	2.4 L/s

Average Consumption Required = 37.0 L/s
Add 25% for future expansion = 46.25 L/s
Add 5% Allowance for Leakage = 48.56 L/s
Total Factory Requirement = 48.56 L/s
To convert L/s - CFM. multiply by 0.03531 and then by 60.

OPERATING PRESSURE

Refer to Page 5

Production Dept. requires 5.5 Bar Gauge.
Assembly & Preparation Depts. need 6 Bar Gauge.
Finishing Dept. 3.5 Bar Gauge, Blow Guns 2 Bar Gauge.
Therefore Maximum Pressure required is 6 bar gauge.
Allow for transmission losses and compressor control differential - use compressor with minimum working pressure of 7 bar gauge. Note 1 Bar = 14.7 pounds/Square Inch (P.S.I.)

FREQUENCY OF AIR DEMAND

Is air demand continuous or variable? In this case it is continuous production therefore we would recommend a vane or screw type compressor in preference to a reciprocating type. Refer to Pages 4 & 5.

ENVIRONMENTAL CONDITIONS

Refer to Page 5.

They need to be clean, cool, well ventilated, with adequate room for maintenance and repairs. Consider local noise level restrictions. In this instance the vane or screw compressors recommended have much lower noise levels than the reciprocating types.

QUALITY OF COMPRESSOR AIR REQUIRED

Consider the financial benefits of getting rid of condensate and oil carry over by fitting a dryer aud main line filtration.

Refer to Pages 5 and 6 and Pages 9 to 14.

Consider the dewpoint required in order to choose the correct type of dryer. Do not use a lower dewpoint than is really necessary as it will increase the running costs without giving any added advantages. In our example the compressor plant is in the same building (no outside air lines) and there is no application requiring a very low dewpoint, so a refrigeration dryer would satisfy the requirements.

FILTRATION

We would need a general purpose filter but there is no application requiring the removal of oil vapour or odour so an oil filter down to 0.01 PPM will suffice.

INSTALLATIQN OF COMPRESSOR PLANT

Consider unloading facilities and electrical requirements of compressor and dryer.

COMPRESSOR STAND-BY CAPACITY

Consider the importance of air supply in relation to needs. Will serious loss be involved if air supply fails? In a production plant the answer is ‘Yes’. Therefore we need more than one compressor so that production is not lost during periods of maintenance or breakdown.

IS THE FACTORY DEMAND VARIABLE?

If so we would need a multiple of smaller compressors which would switch on and off automatically according to air demand and thereby save energy.

In our example it is continuous production so we only need 2 compressors - 1 on duty and 1 on stand-by.

Easy approx. conversion for Litres/second to cubic feet/minute. L/s x 2 + 10% or for greater accuracy L/s x 2 + 6%. 1 Bar equals 14.7 pounds/sq. inch.

SERVICING

Are spares and service easily available? Also consider preventive maintenance i.e. A contract service facility.

MAIN FACTORY PIPING SYSTEM

Refer to Pages 17 and 18.

In our example an ideal, reliable system would need:
2 off 25 H.P. vane or screw compressors. 50 L/s (106 CFM)
1 off Vertical air receiver to match would be 500 litres (17 cu.ft.) capacity
1 off Refrigeration dryer. Minimum flow at 30°C inlet temp.
1 off General purpose filter
1 off Oil removal filter to 0.01 PPM
Factory Piping would be closed loop (Ring Main)
2" N.B. Pipe for mains with l/2" drop feed lines
Dryer and Filters would have a 3-valved bypass system.
Filters would have pressure drop indicators to indicate need to change elements.
Automatic Drain Valves on receiver, aftercooler and filters.

PREFERRED METRIC UNITS

Compressor and tool manufacturers prefer Litres, up to 1000 (L) and cubic metres (M^3) above 1000L

Pneumatic equipment manufacturers prefer cubic decimetres, dm^3.

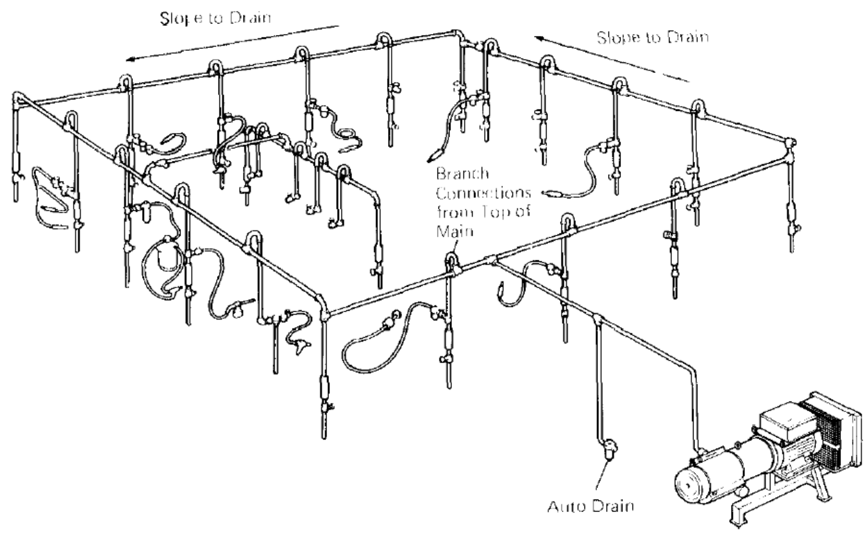
Normally quoted as Free Air at specified conditions in the case of air compressors, the conditions are those prevailing at the air compressor inlet.

For pneumatic tools and control equipment the conditions are those at standard reference atmosphere (ANR). Use of the letters ANR (Atmosphere Normale De Reference) after the rate of flow indicates that the flow is Free Air at standard atmosphere conditions. Unless otherwise stated pressures in Bar are assumed to be gauge pressures.

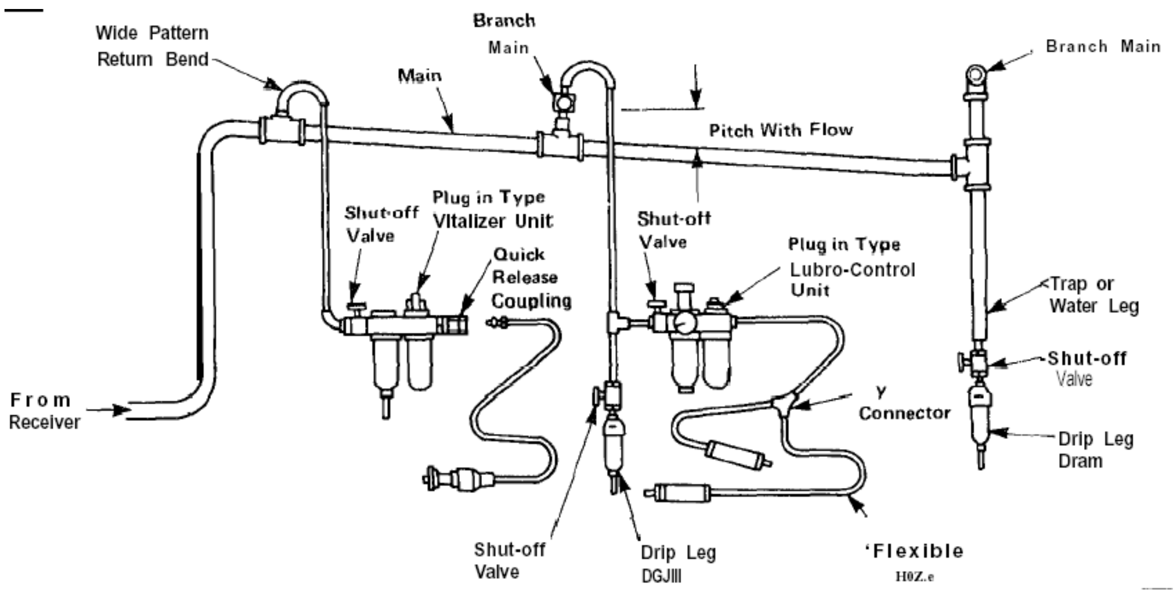
References for further information on S.I. units are ISOlOOO,

BS5555, CETOP RP71 and BSI Publication PD 5686 1978.

A TYPICAL COMPRESSED AIR PIPEWORK SYSTEM



CORRECT AIRLINE INSTALLATION



Compressed air systems

PRESSURE SYSTEMS REGULATIONS

Pressure Systems and Transportable Gas Container Regulations 1989 Statutory Instrument 1989 No. 2169

The above Regulations came into force on 1st. July 1990 and as a user/owner of a compressed air system you are directly responsible for ensuring that your system complies with these regulations. One of your responsibilities will be to draw up, or certify a 'written scheme of examination' for your air system, which must be carried out by a legally 'competent person'.

Whom does it affect?

Owners and Users of compressed air installed or portable, existing or new

Those who design compressed air systems and components:

Those who manufacture compressed air systems and components

Those who install compressed air systems

Those who maintain compressed air systems

Those who import compressed air systems and components

Those who supply compressed air systems

Competent Persons and Examiners

Components which should be included in each Scheme of Examination

1. Air receivers.
2. Air/Oil separator vessels of screw compressors.
3. Pressure relief valves (Safety Valves).
4. Pressure gauges and temperature gauges.
5. Filters and lubricators with plastic bowls.
6. Filters and automatic drain valves with metal bowls.
7. Pressure switches if failure could give rise to danger.
8. Oil and/or air temperature controls of compressors.
9. Oil level controls of oil flooded compressors.
10. Intercoolers of two stage compressors.
11. Pipework of reciprocating compressors between compressor and aftercooler
12. Any metallic pipework which is located in a position where,failure could give rise to personal injury
13. Fusible plugs and bursting discs.
14. Any aftercoolers with headers exceeding 250 bar litres.
15. Pressure regulators if regulator failure could result in the rupture of the downstream pipework or equipment

Our Company is a 'Competent Person' as defined in the Pressure Systems Legislation and is therefore fully qualified to draw up a 'Written Scheme of Examination' and to carry out such examinations.

If you require advice, or are in doubt regarding your responsibilities under these regulations or if you wish us to act as your 'Competent Person' please do not hesitate to contact any of our Centres listed on the back page.

Suggested Reading

The British Compressed Air Society have published a guidance and interpretation document covering these Regulations which is available from our Group of Companies entitled 'Owners and Users Guide' Part 4.

Easy approx. conversion for Litres/second to cubic feet/minute. L/s x 2 + 10% or for greater accuracy L/s x 2 + 6%. 1 Bar equals 14.7 pounds/sq. inch.

TABLE1

AIR CYLINDER THRUSTS AND CONSUMPTIONS

0 mm	0 approx inches	Thrust Newtons	Thrust lb.	Air Usage- litres per mm stroke
250	10	27080	6085	.316
200	8	17330	3895	.202
160	6 1/4	11090	2490	.130
125	5	6770	1520	.079
100	4	4330	973	.051
80	3 1/8	2770	623	.032
63	21/2	1720	386	.020
50	2	1080	243	.013
40	11/2	693	156	.0081
32	11/4	443	100	.0052
25	1	270	61	.0032
20	3/4	173	39	.0020
16	5/8	111	25	0013
12	1/2	62.4	14	.0007

For cylinders smaller than 012. theoretically derived figures become meaningless because of the increased significance of factors which may safely be ignored in cylinders of larger diameter. Figures apply to non-cushioned cylinders at 80 psi (5.52 bar)

Thrust - varies directly with pressure. At 60 psi, thrusts are three-quarters of those shown: for thrusts exerted by cylinders fed with air at 100 psi, multiply figures from the table by 1.25.

Thrusts given are gross theoretical; as a rule of thumb, when selecting cylinders multiply required thrust by 1.5 then choose the next larger bore.

Example: Thrust required - 400 lb. Pressure available - 80 psi. 400 x 1.5 = 600. Therefore use 080 cylinder (delivers 623 lb.)

4ir Consumption - is given in litres of free air per mm of stroke. To convert litres to cubic feet, multiply by 0.0353.

Example: What is the air consumption for a cylinder 080, 100mm stroke, supplied with air at 80 psi, for three complete cycles (extend + retract)?

3.032 x 100 x 3 x 2 = 19.2 L/s 19.2 x 0.0353 = 0.678 cu. ft

Consumption will be greater at pressures higher than 80 psi, less at lower pressures.

TABLE2

AIR CONSUMPTIONS OF AIR TOOLS

	Consumption per unit L/sec	Typical Use Factor	Average Consumption L/sec
Blow Gun	*2 - 8	0.10	0.2 - 0.8
Drill			
Light	6	0.20	1.2
Medium	8	0.20	1.6
12mm	15	0.30	4.5
Grinder			
Medium	23	0.10	2.3
Heavy	42	0.10	4.2
Air Hammer			
Light	6	0.35	2.1
Medium	8	0.35	2.8
Heavy	13	0.20	2.6
Hacksaw/File	7	0.20	1.4
Hoist			
500 kg	33	0.10	3.3
5 tonne	97	0.05	4.9
Impact Wrench			
Light	6	0.20	1.2
22mm	23	0.10	2.3
Sand Blast Unit	*5 - 42	0.50	2.5 - 21
Sander			
Hi-Speed	12	0.35	4.2
Orbital	11	0.50	5.5
Shear (to 14SWG)	9	0.50	4.5
Spray Gun	*2 - 15	0.50	1 - 7.5
Vacuum Cleaner	*2 - 10	0.20	0.4 - 2

The table gives typical free air consumption figures for air tools and appliances. *These figures are governed by the size of nozzle used.

When assessing compressor requirements it is important to work with the compressor manufacturer's 'F.A.D.' characteristic which states the actual Free Air Delivered. It should also be remembered that consumption tends to increase as tools age.