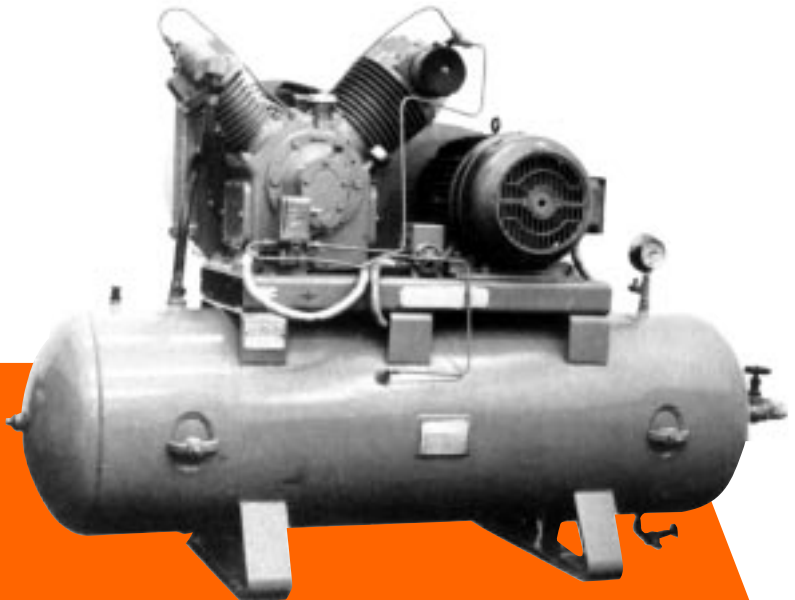


A Guide to the Construction, Installation, Operation and Maintenance of Air Receivers



Occupational Safety and Health Branch
Labour Department



Occupational Safety and Health Council

This guide is prepared by
the Occupational Safety and Health Branch
Labour Department

This edition August 2016

This Guide is issued free of charge and can be obtained from office of the Boilers and Pressure Vessels Division of the Occupational Safety and Health Branch or downloaded from website of the Labour Department at http://www.labour.gov.hk/eng/public/content2_10.htm. Address and telephone numbers of the office can be found in the website of the Department at <http://www.labour.gov.hk/eng/tele/bpvd.htm>.

This guide may be freely reproduced except for advertising, endorsement or commercial purposes. Please acknowledge the source as “A Guide to the Construction, Installation, Operation and Maintenance of Air Receivers”, published by the Labour Department.

A GUIDE
TO THE
CONSTRUCTION, INSTALLATION,
OPERATION AND
MAINTENANCE OF AIR RECEIVERS

Boilers and Pressure Vessels Authority
Labour Department

CONTENTS

<i>Section</i>		<i>Page</i>
1.	DEFINITIONS	7
2.	INTRODUCTION	9
3.	CONSTRUCTION	10
4.	DESIGN CODES	18
5.	STATUTORY REQUIREMENTS	20
6.	REGISTRATION	21
7.	CERTIFICATE OF FITNESS	22
8.	STATUTORY EXAMINATIONS	23
9.	INSPECTION AND MAINTENANCE	26
10.	RECORDS	31

FOREWORD

The safety of pressure equipment in operation depends ultimately on a thorough understanding of the equipment, regular inspections and periodic maintenance and, above all, a conscious realisation amongst all concerned for the safety. This Guide aims at presenting essential technical details and statutory requirements in simple language for ease of assimilation and, thereby, inculcating a higher degree of safety awareness. The information included is by no means exhaustive but adequately covers the general subject of air receivers construction, operation and maintenance. In special circumstances, such as receivers for use in corrosive environment, particular consideration shall be given and the makers consulted.

The Boilers and Pressure Vessels Ordinance and its associated regulations have been extensively quoted as these provide effective guidelines for the safety in use of this equipment. Various makers manuals and their recommended procedures have also been carefully considered in preparing this Guide. However, this Guide is not meant to supersede any recommendations published by the makers in the manual about their equipment.

It is realised that some of the recommendations made may not strictly apply to certain air receivers in use in Hong Kong. This is unavoidable as wide variety of such equipment is imported in Hong Kong. The owners are advised to consult the equipment manufacturers and, if necessary, the appointed examiners or the Boilers and Pressure Vessels Division whenever in doubt.

By an intelligent interpretation of recommendations in this Guide, read in conjunction with the Ordinance, safety in the use of air receivers will continue to be ensured. This Guide will prove useful to owners, appointed examiners and all other personnel concerned with the manufacture, operation, and maintenance of the air receivers.

It is, however, emphasised that in case of any inconsistency between the law and this Guide, the law will prevail.

SECTION 1 DEFINITIONS

The terminology used in this Code conforms to the Boilers and Pressure Vessels Ordinance and is reproduced below for ease of reference.

Air Receiver

- 1.1 (a) any vessel (other than a pipe or coil, or an accessory, fitting or part of a compressor) for containing compressed air and which is connected with an air compressing plant;
- (b) any fixed vessel for containing compressed air or compressed exhaust gases that is used for the purpose of starting an internal combustion engine; and
- (c) any fixed or portable vessel (not being part of a spraying pistol) used for the purpose of spraying, by means of compressed air, any paint, varnish, lacquer of similar material.

Air Receiver Inspector

- 1.2 A person who has been appointed by the Chief Executive to be an air receiver inspector and whose appointment to be an air receiver inspector has not been suspended.

Appointed Examiner

- 1.3 A boiler inspector or an air receiver inspector who has been appointed by the Chief Executive and whose appointment has not been suspended.

Certificate of Fitness

- 1.4 A certificate issued by an appointed examiner upon examination of the air receiver after he is satisfied that the air receiver, its fittings and attachments are in safe working order and the equipment may safely be used and operated at the specified maximum permissible working pressure.

Certificate of Inspection during Construction

- 1.5 A certificate issued by an appointed examiner or a recognised inspection body in respect of the air receiver certifying that the air receiver, its auxiliary equipment, was inspected during its construction.

Division

- 1.6 The Boilers and Pressure Vessels Division of the Labour Department.

Makers' Certificate

- 1.7 A certificate issued by the manufacturer of the air receiver certifying that he has constructed the air receiver, and that the particulars stated in the certificate relate to such air receiver.

Maximum permissible working pressure

- 1.8 Maximum working pressure at which the air receiver is allowed to operate.

Recognised

- 1.9 Recognised means recognised by the authorised officer in the Labour Department.

Registered

- 1.10 An air receiver that is entered in the register of air receivers maintained by the Labour Department.

SECTION 2 INTRODUCTION

Operating Principles

- 2.1 Air receiver acts as a reservoir for the storage of compressed air and absorbs pulsations in the discharge line from the compressor. A steady flow of air is thus provided to the service line. Any moisture or oil present in the air as it carries over from after-coolers to the air receiver will be separated out in there. Air receiver should therefore be placed in a clean and well-ventilated location, and be set off the ground, on concrete blocks or on a suitable foundation, as the dampness on the ground causes excessive rusting and corrosion around the bottom. The bottom seams should be kept clean and well painted at all times. Sufficient access to allow visual inspection must always be provided all around the body of the receiver.
- 2.2 The air receiver must be of sufficient capacity or the differential pressure switch setting must be wide enough to avoid short cycling of an air compressor i.e. frequent start and stop. The pressures and frequency at which the compressor unit starts and stops on load have to be monitored within the limits recommended by the manufacturer. The air receiver must be drained regularly to remove the condensate accumulated in order to avoid water being carried over to the down-stream air supply line and prevent corrosion. Whenever the air compressor or receiver is to be taken out of service for long period of time, the receiver should be drained and stored in a dry sheltered location. It is recommended that air receiver be dried out after draining, inspected before storage and re-inspected before putting back into commission.

Compliance with recognised standards

- 2.3 There is extreme danger in the use of air receivers of unsound or questionable construction. In the interest of safety, it is essential that the air receivers are manufactured strictly in accordance with a reputable engineering standard or code. Some of the relevant standards are included in Section 4 for reference.

SECTION 3 CONSTRUCTION

Standard Fittings

- 3.1 Standard air receiver is furnished complete with drain valve, pressure gauge, pressure switch, safety valve, inspection opening and suitable foundations. Some of the essential fittings are briefly described below. Makers' manuals for each component should be carefully studied to fully understand operating principles and maintenance requirements. Any instructions given in the manuals must be explicitly followed.

Shell and End Plates

- 3.2 Both cylindrical shell and end plates are each, preferably, made from a single plate. If the cylindrical shell and end plates cannot possibly be made from a single plate, they shall be made with minimum number of joints and the longitudinal seams in adjacent sections shall be as far as practicable. Longitudinal seams should not pass through nozzles or openings. All weldings should be carried out by welders who have been tested to the relevant National Code. All the materials used in the manufacture of the receivers shall comply with the requirements of the relevant design code, and be identifiable with mill sheets. The selection of materials of the shell shall take into account the suitability of the materials with the maximum working pressure and fabrication process. It is recommended that vibration dampers or vibration isolators should be fitted between the compressor and the air receiver. Failure to do this may result in vibrations being transmitted to the receiver and causing fatigue cracks to appear in the body of the receiver. Figure 1 illustrates the general arrangement of the air compressing system.

Inspection openings

- 3.3 Every receiver shall be provided with openings for internal examination and maintenance. Inspection openings shall not be situated near a welded seam and, where necessary, compensation ring shall be fitted in order to offset the effect of discontinuities in the proximity of the openings. There are various types of inspection openings fitted on the receiver, such as, sight hole, hand hole, head hole and manhole. Reference can be made to an engineering standard for details.

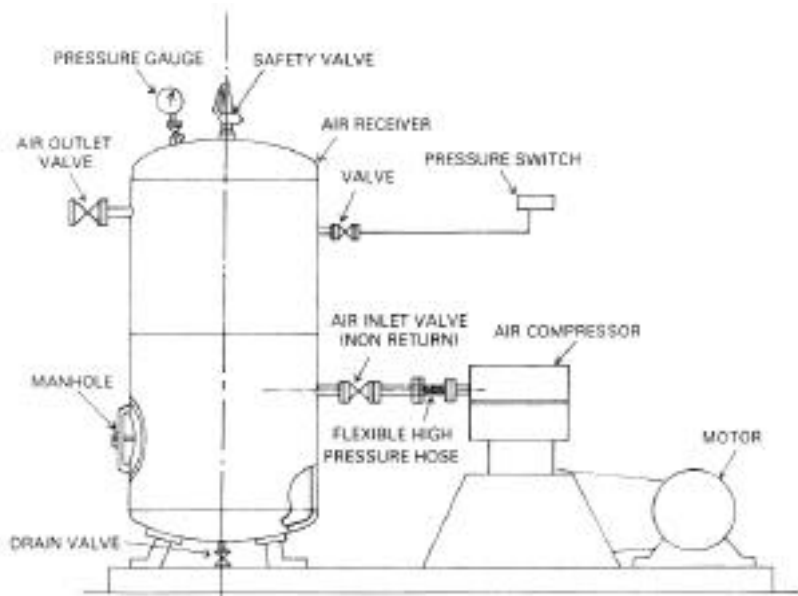


FIG 1 GENERAL ARRANGEMENT OF AIR COMPRESSING SYSTEM

Safety valve

3.4 The safety valve should be fitted on the air receiver to prevent excessive pressure build-up in-case of any malfunction or the unloading apparatus failing to function as envisaged. These valves should be of sufficient size and properly set so as to allow air to discharge as soon as the maximum permissible pressure is exceeded for that part of the system. The valve shall be installed with suitable easing gear and at a position where discharging air will not be liable to cause injury to staff working in its proximity or any passer-by. The safety valves for compressed air systems should preferably be of spring-loaded type and be so designed as to prevent unauthorized interference with the valve setting. Any fittings on the receiver should not affect the operation of safety valve. Safety valve must not be isolated from the system or any part of the system by fitting an isolating valve or stop valve or stop cock. Safety valves should be clearly marked with their nominal operating pressure and, where practicable, their discharge coefficient. In operation, safety valve should be tested at intervals to avoid the possibility of sticking. *Safety valve should be dismantled and inspected at every periodical examination.* Valves undergoing test shall not be approached for close inspection until after the test pressure has been reduced to a safe level. Fig. 2 illustrates a typical design of the safety valve commonly used on air receivers.

Setting of safety valve

3.5 The safety valve should only be set by an appointed examiner. Setting of the valve blow-off pressure is described below:–

- (i) adjust the pressure switch to allow compressor cut off at a higher pressure;
- (ii) bring air pressure to that slightly above the blow-off pressure;
- (iii) slack off the adjusting screw until the valve lifts;
- (iv) maintain the receiver at blow-off pressure, and gradually slack off adjustment screw until the valve lifts again;
- (v) screw down the adjusting screw very slightly so that the valve spindle is tapped down lightly on the valve lid;
- (vi) tighten the lock nut and valve cap;
- (vii) re-adjust the compressor high pressure cut-off in the pressure switch to its original pre-determined value.

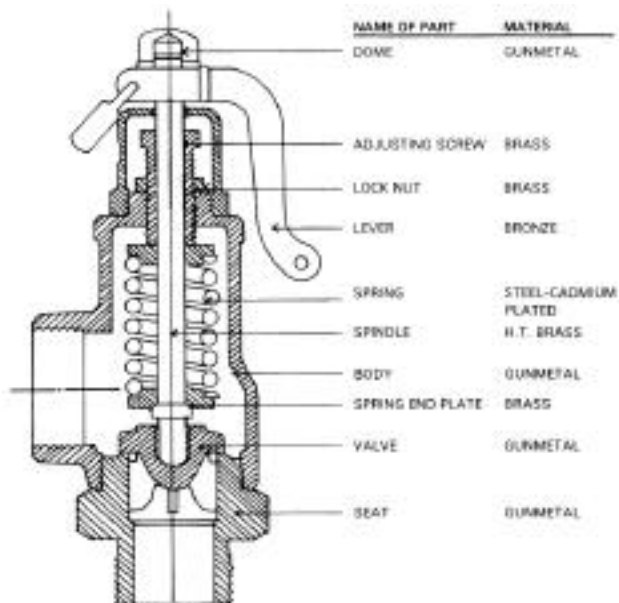


FIG 2 SAFETY VALVE

Bursting discs

- 3.6 Bursting discs used should be as close as practicable to the part of the system they are intended to protect. The discharge pipe should be of ample size, as straight and short as possible and should terminate in such a way as to avoid dangerous or damaging conditions arising on discharge. They should be mounted so that they are readily accessible for replacement and protected from accidental damage. Consideration should be given to the effects of weather, including freezing of the discharge outlets and possible corrosion.

Draining devices

- 3.7 Either manually operated valves or suitable automatic valves may be used. Threaded plugs are not recommended to be used. The drain valve should be located at the lowest point of the receiver for draining off at regular intervals any accumulated water, oil or other impurities. Ensure that the drain valve is not left partially open otherwise wastage will result. A check on the drainage may also determine whether the cylinder is properly lubricated. If excessive amount of oil is precipitated in the receiver it indicates that the compressor cylinder is being over-lubricated. Fig. 3 illustrates a typical view of an auto-drain valve.

Pressure indicating devices

- 3.8 The devices should be selected and fitted taking into account the operating conditions likely to be met, e.g. rapid pressure changes, vibration, ambient temperature etc. They should be fitted so that they are easily visible to the operator and, where necessary, repeater devices should be provided. These devices should have a reasonable range beyond the operating pressure of the air receiver and be fitted with an isolation cock in case the devices require maintenance. Pressure gauges with full scale deflection reading more than 3 times the operating pressure shall not be used. The isolation cock should be so designed that the handle is in line with the direction of air flow when the cock is open.

There should be adequate clearance between the back of any pressure gauge fitted with a blowout back and without any obstruction so that any discharged air can easily be vented. Glass used for the air receiver where the pressure is liable to exceed 1 000 kPa (10 bar) should have splinter proof glass. Pressure gauges should be calibrated against standard gauges at regular intervals, making necessary adjustment if a discrepancy is found. The mountings for test pressure indicating devices (if fitted) should be separated from the mounting for the pressure indicating device for operational purposes. Fig. 4 illustrates a Bourdon pressure gauge installed on an air receiver.

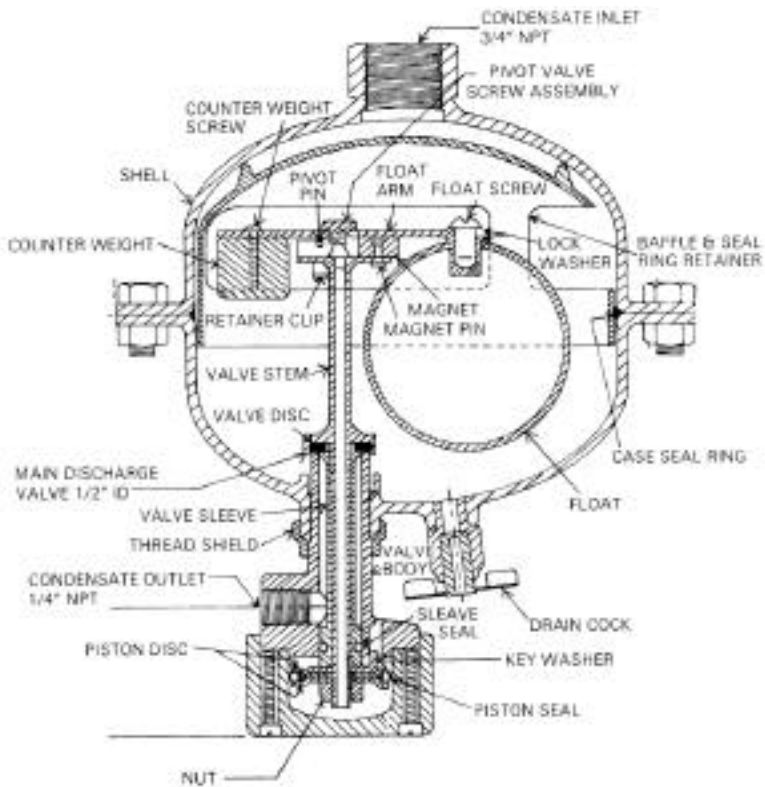


FIG 3 AUTO DRAIN VALVE

Operation

This auto-drain valve is of a pilot-actuated and power-operated type, which discharges condensate from compressed air lines efficiently and automatically. As condensate inside the shell rises, the float is prevented from rising by a magnet mounted on the valve stem. When float buoyancy overcomes magnetic attraction, float actuates the pilot valve open allowing system air pressure to act on piston. System air pressure forces the piston upward, opening the Main Discharge Valve. Condensate is forced through this valve. When sufficient condensate has been discharged, the float drops and the magnetic attraction on the float arm causes snap closing off of the pilot valve, cutting off the air supply to the piston. Piston assembly then returns to original position, closing the Main Discharge Valve.

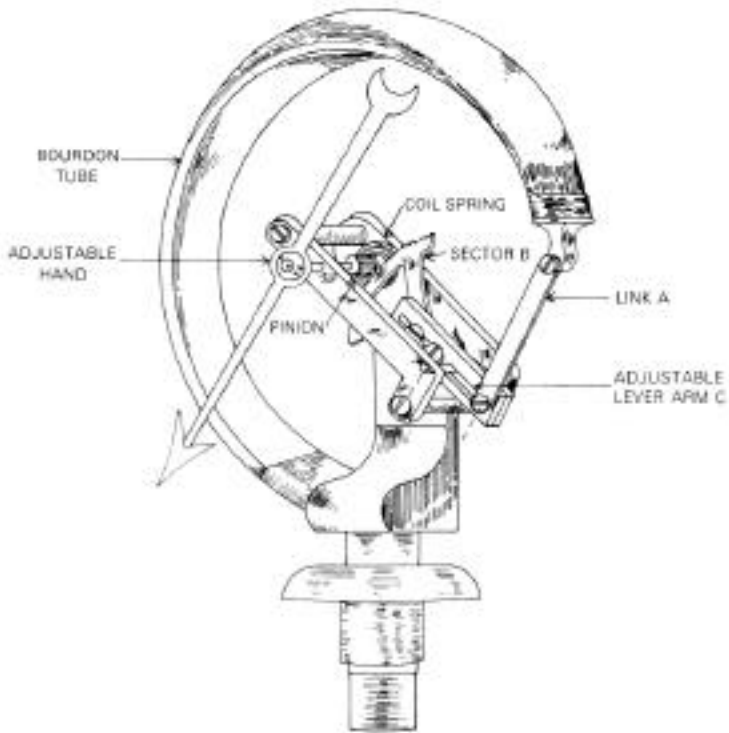


FIG 4 BOURDON PRESSURE GAUGE (INTERIOR VIEW)

Reducing valve

3.9 Reducing valves should be correctly selected taking into account the operating pressure, pressure difference and rate of air flow. Fig. 5 shows the details of a typical reducing valve. Pressure gauges should preferably be installed before and after the reducing valve.

Non-return valves

3.10 The direction of air flow should be marked on the non-return valves.

Isolating and stop valves

3.11 The direction of turning to open/close should be indicated on valve together with the function of the valve where this is not obvious.

Pressure switch

3.12 The aim of fitting a pressure switch is to provide an automatic control on the air compressor. With the installation of such device the compressor can be started and stopped by the change of air pressure in the receiver. Basic form of the switch essentially consists of a bellow, springs, adjusting screws and electrical contacts. A typical view of the pressure switch is shown in Figure 6.

Setting of pressure switch

3.13 Before adjusting the pressure switch, makers' manual should be studied carefully. The following description gives a general procedure for pressure switch adjustment.

- (i) first, set the high pressure cut-out by means of the range adjusting screw (i.e. the pressure at which the compressor motor stops);
- (ii) next, set the low pressure cut-in by means of the differential adjusting screw (i.e. the pressure at which the compressor motor starts)

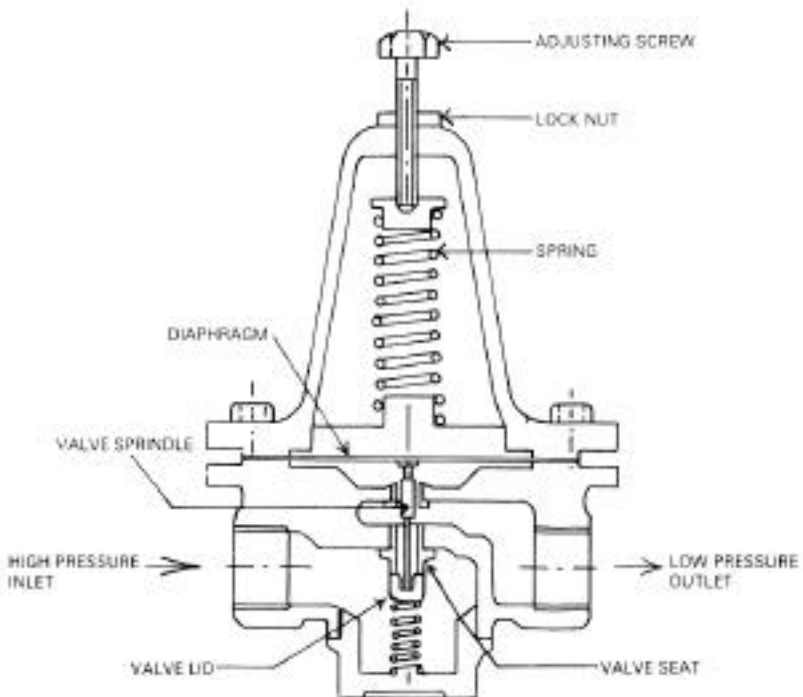


FIG 5 REDUCING VALVE

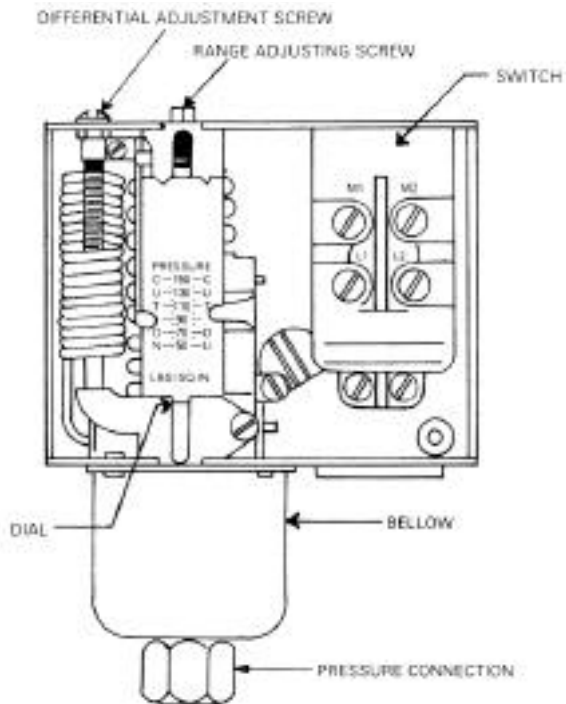


FIG 6 PRESSURE SWITCH

SECTION 4 DESIGN CODES

Design codes

- 4.1 There are many engineering standards which give information on the design, construction and fittings of an air receiver. The relevant British Standards are normally followed in Hong Kong, but other national or international standards may also be used. It is, however, emphasised that any standard selected for manufacture of the air receiver must be followed and complied with in entirety and the design must not be based on provisions from different standards. In case of any doubt, reference can be made to the Boilers and Pressure Vessels Division.
- 4.2 Some of the relevant British Standards and other national standards are listed below for ready reference. Current edition of respective standards should be complied with. Deviations from relevant standard, if any, should be indicated by the appointed examiner.
- (a) Design and Construction
- (i) BS 470 'Access and inspection openings for pressure vessels';
 - (ii) BS EN 286 'Fusion-welded steel air receiver';
 - (iii) PD 5500 'Unfired fusion welded pressure vessels';
 - (iv) BS 1101 'Specification for pressure container for paint and other substances';
 - (v) ASME 'Boilers and Pressure Vessel Code – section VIII Division 1 and Division 2';
 - (vi) JIS-B8265 'Japanese Industrial Standard – Construction of Pressure Vessels';
 - (vii) BS EN ISO 15614 Approval testing of welding procedures;
 - (viii) BS 4871 Approval testing of welders working to approved welding procedure;
 - (ix) ASME Welding and Brazing Qualifications – Section IX.
- (b) Safety Fittings & Ancillaries
- (i) BS 1123 'Specifications for safety valves, gauges and other safety fittings for air receivers and compressed air installation'.
 - (ii) BS EN 837 'Bourdon tube pressure and vacuum gauges'; and
 - (iii) BS EN ISO 4126 'Bursting discs and bursting disc assemblies'.

Design information and marking

- 4.3 Basic information about an air receiver should be provided by means of permanent markings on the receiver, or a plate permanently attached to the receiver. Such information includes as a minimum requirement the manufacturer's name, and identifying number, the maximum permissible working pressure and the capacity of the air receiver.
- 4.4 Such marks may be made by stamping, embossing, engraving or other method giving similar permanence and should be applied in such a manner and position that they do not affect the integrity of the receiver. Appropriate SI (System International d'Unites) units should be used.
- 4.5 Additional information about air receivers and any other information relevant to the whole system should be provided in writing. Where the document provided is not written in English, it shall be accompanied by an English translation. Such information should include at least the relevant parts of the following:–
- (i) Design standards used, together with appropriate certificate of conformity under those standards;
 - (ii) Certification of parts by an inspection authority;
 - (iii) Design pressures (maximum and minimum);
 - (iv) Design temperatures (maximum and minimum);
 - (v) Results of any tests done on the air receiver during manufacture; and
 - (vi) Maximum loads the parts or supports are designed to carry.

SECTION 5 STATUTORY REQUIREMENTS

Boilers and Pressure Vessels Ordinance Cap. 56

5.1 This Ordinance and its associated legislations control the use and operation of air receivers installed in Hong Kong. The owners of air receivers are advised to familiarise themselves with the requirements laid down in this Ordinance and its associated regulations. The appointed examiners can assist owners in compliance with the law. In case of any difficulties, the Boilers and Pressure Vessels Division can also be consulted.

Safety requirements to air receivers

5.2 The essential requirements are briefly described below for ready reference. The law requires that every air receiver shall:–

- (a) where the air receiver is connected to a compressor, be so constructed as to withstand with safety the maximum pressure that can be obtained in the compressor or be fitted with a suitable reducing valve or other suitable appliance to prevent the maximum permissible working pressure of the air receiver being exceeded;
- (b) be fitted with a suitable spring-loaded safety valve;
- (c) be fitted with a correct pressure gauge in S.I. Units (kPa or multiples of kPa) to indicate the air pressure in the receiver;
- (d) be fitted with suitable appliance for draining the air receiver;
- (e) be provided with suitable manhole, handhole or other means to allow the interior to be thoroughly cleaned;
- (f) where more than one air receiver is being used by the same owner in any industrial undertaking, bear a distinguishing mark which shall be easily visible;
- (g) be legibly marked with the maximum permissible working pressure and the date of last examination; and
- (h) where the safety valve is not fitted directly to the air receiver, be fitted with a suitable fusible plug.

Combination of Air Receivers

5.3 In case any set of air receivers are supplied with air through a *single* pipe, then safety valve and pressure gauge may be fitted by treating the set as one air receiver. However, if any one air receiver is required, by virtue of Para. 5.2(a), to be fitted with a reducing valve or other appliance to prevent the maximum permissible working pressure of the air receiver being exceeded, the set shall not be considered as one air receiver unless the reducing valve or other appliance is fitted on the said single pipe.

SECTION 6 REGISTRATION

Application for registration

- 6.1 The owner of a new air receiver shall, not later than 30 days preceding the day on which he intends to put the same into use, apply to the Boilers and Pressure Vessels Division on the prescribed form for its registration under the Ordinance. Other relevant documents required for submission to this Division shall include :-
- (a) where the air receiver was constructed in Hong Kong, one copy of the certificate of inspection during construction; or
 - (b) where the air receiver was not constructed in Hong Kong, one copy of the maker's certificate and one copy of a certificate issued in respect of the air receiver by a recognised inspection body in the country in which it was constructed.

Registration Number

- 6.2 A registration number shall be allotted to the air receiver after the particulars of the air receiver are entered in the Register and maintained at the Division. The owner of a registered air receiver shall cause the registration number allotted to be engraved, whether by impression or incision, in a conspicuous position on the air receiver and it should be clearly legible at all times.

Sale or Hire

- 6.3 The owner of a registered air receiver, who sells or hires it to any person shall, within 7 days of the sale or the agreement for hire, notify the Division of the name and address of the person to whom the air receiver has been sold or hired and, where the air receiver is not so designed as to be transportable from one place to another, shall also notify the Division whether or not the sale or hiring has resulted or will result in the removal of the same.

Change of address

- 6.4 The owner of a registered air receiver shall, within 7 days of the change, notify the Division of any change of his/her address.

SECTION 7 CERTIFICATE OF FITNESS

- 7.1 Every new air receiver and its fittings and attachments shall be examined by an appointed examiner before it is put into use. It shall, subsequently, be re-examined by an appointed examiner within 26 months after the date of any certificate of fitness has been issued.
- 7.2 A certificate of fitness in respect of an air receiver shall be issued by an appointed examiner who is satisfied with the conditions of the air receiver and its fittings after the examination of the air receiver. List of approved appointed examiners can be obtained from the Boilers and Pressure Vessels Division.
- 7.3 An appointed examiner shall deliver to the owner of the air receiver 2 copies of the certificate. After the copies are delivered to him, the owner shall, within 7 days, deliver one copy to the Division, and keep one copy at the premises at which the air receiver is installed.

Examination after extensive repairs or on change of premises

- 7.4 If an air receiver that is not designed to be transportable has been relocated to new premises, or has been removed from one part of any premises to another part thereof, it shall, together with its fittings and attachments, be examined by an appointed examiner before it is put into use in the premises. Also if an air receiver has extensive repairs carried out, it shall, together with its fittings and attachments, be examined by an appointed examiner before it is again put into use.
- 7.5 The appointed examiner may refuse issue of a certificate of fitness after such an examination if he is not satisfied with the condition of the air receiver or its fittings and attachments, or the pipe connecting the air receiver.

SECTION 8 STATUTORY EXAMINATIONS

Examination for new air receiver

- 8.1 Every new air receiver and its fittings and attachments shall be examined by an appointed examiner before it is put into use. The examination shall include the following:—
- (i) where an appointed examiner considers it necessary, the air receiver shall first be examined by him when it is not under pressure;
 - (ii) where an appointed examiner considers it necessary, the air receiver shall be subjected to hydraulic test;
 - (iii) in every case, the air receiver shall be examined under the maximum permissible working pressure specified in the certificate of fitness; and
 - (iv) the air receiver shall be subjected to a pressure accumulation test by an appointed examiner.

Periodic Examination of Existing Air Receiver

- 8.2 Every air receiver including its fitting and attachments shall be examined at an interval not longer than 26 months. The owner of the air receiver shall cause the air receiver and all its fittings to be thoroughly cleaned and accessible for examination by an appointed examiner. If the appointed examiner is of the opinion that the air receiver should require immediate repairs in order to maintain it in safe working order, he shall notify the owner of the air receiver of the repairs that he considers necessary. An air receiver shall next be subjected to a hydraulic test by an appointed examiner when
- (i) any extensive repairs have been carried out;
 - (ii) the size or design of the air receiver does not permit an internal examination readily; or
 - (iii) an appointed examiner considers it necessary.
- 8.3 Finally, the air receiver shall be examined by an appointed examiner under the pressure specified in the certificate of fitness as the maximum permissible working pressure and the safety valve will be subjected to a pressure accumulation test if he considers it necessary.

8.4 *Examination after extensive repair*

Every air receiver, after extensive repairs have been carried out, shall be examined by an appointed examiner before it is again put into use. In the course of examination by an appointed examiner, he will ensure that the welders employed for the repairs are properly qualified in accordance with a recognised standard and an approved welding procedure has been used for welding. He shall arrange for the air receiver to be hydraulically tested and, therefore, examined under the maximum permissible working pressure specified in the certificate of fitness. Finally, if an appointed examiner considers it necessary, a pressure accumulation test shall be carried out, using air at the maximum permissible working pressure from the compressing unit connected, to check that the safety valve is set correctly and its size is adequate to discharge the compressing unit output without exceeding the allowable limit of pressure inside the air receiver. Normally, the increase in pressure in the air receiver should not exceed 10% of the design working pressure.

Hydraulic tests

- 8.5 Hydraulic test should be carried out to the satisfaction of the appointed examiner. All tests shall be made with water. Where other liquids are used, they must be non-hazardous and additional precautions may be necessary depending on the nature of the liquid. Consideration shall be given to possible deleterious effect of the pressurizing agent on the material of the receiver e.g. small traces of chlorides etc., in water may be harmful in austenitic chromium-nickel steels. Attention is drawn to the effect of temperature change of water so as to preclude the possibility of brittle fracture. Care shall be taken to prevent the trapping of air in the receiver and in any of its connections. In practice, the receiver and its connections should be purged of the trapped air before applying further pressure. The receiver shall be adequately supported to withstand the forces due to its own weight plus that of water and any other forces. The test pressure shall not be applied until the receiver and its pressurizing agent are at about the same temperature. The pressure shall be raised slowly and steadily to the specified figure and final test pressure shall be maintained for sufficient time as may be required by the appointed examiner to permit a thorough examination. Instrument and fittings for which the maximum permissible test pressure is lower than the test pressure applied shall be removed or blanked off from the system before testing to avoid damage.
- 8.6 Due to the possibilities of any undetected defects in the receiver, hydraulic test can give rise to a catastrophic accident. Test procedure and safety precautions prior to application of pressure shall therefore be established to ensure the highest practicable standard of safety.

8.7 Upon completion of the hydraulic test, the appointed examiner should further examine the condition of the receiver to ascertain that all parts of the receiver are not affected by the hydraulic test pressure.

8.8 *Hydraulic test pressure*

Before any hydraulic test is carried out, the appointed examiner should ascertain the maximum permissible working pressure of the air receiver in order to determine the test pressure. The hydraulic test pressure shall be determined as follows:–

Where P_t = hydraulic test pressure

P = maximum permissible working pressure

(a) in the case of a seamless steel air receiver:–

(i) for maximum permissible working pressure not exceeding 14 000 kPa

$$P_t = 2 \times P$$

(ii) for maximum permissible working pressure between 14 000 kPa and 28 000 kPa

$$P_t = P + 14\,000 \text{ kPa}$$

(iii) for maximum permissible pressure exceeding 28 000 kPa

$$P_t = 1.5 \times P$$

(b) in the case of other air receivers:–

(i) for maximum permissible pressure not exceeding 700 kPa

$$P_t = 2 \times P$$

(ii) for maximum permissible pressure exceeding 700 kPa

$$P_t = 1.5P + 350 \text{ kPa}$$

SECTION 9 INSPECTION AND MAINTENANCE

Internal inspection

- 9.1 Subsequent to the removal of all pipework and connectors to the receiver, interior of the receiver should be thoroughly cleaned. Attention should be paid to the surface for any sign of corrosion and damage to the material in particular the *welded seams*. On completion of inspection and any maintenance, the receivers should be cleaned and free from loose scale and other foreign matter.

External inspection

- 9.2 Clean the exterior of the receiver with warm water of any dust, dirt or grease, and remove any corrosion from surface if exists. Dry with clean cloth before carrying out inspection. Inspect all threaded ports for damage and distortion. Carry out repair as necessary. Visually examine the exterior of the receiver for any sign of corrosion, scoring or scratches, distortion or any other form of physical damage on the material, particular attention must be paid to the welded seams. Should storage after cleaning is to be required, even temporarily, all openings must be sealed off to prevent the ingress of dust and dirt to the inside of the receiver.

Corrosion

9.3 (a) *Types of corrosion*

The pattern of corrosion generally experienced may be classified as follows:–

- (i) General corrosion is that which has caused the reduction in wall thickness over an area exceeding 20% of the surface;
- (ii) Area corrosion is that which has caused the general reduction in wall thickness over an area NOT exceeding 20% of the receiver surface. It excludes other types of corrosion described;
- (iii) Chain pitting and line corrosion may occur along all or part of the length of the receiver surface and also around the wall circumference of vertically mounted receiver. They are made up of a series of pits or corroded cavities on the wall surface and generally are of limited width;
- (iv) Channel corrosion is a more concentrated form of line corrosion or a channel formation in the metal;
- (v) Isolated pits are pitting of the metal in isolated areas.

(b) *Rejection Criteria*

An air receiver must be rejected and replaced when any of the following situation applies:–

- (i) for general corrosion, if the depth of penetration exceeds 20% of the original wall thickness or if the original metal surface is badly distorted;
- (ii) for area corrosion, if the depth of penetration exceeds 25% of the original wall thickness or if the original metal surface is badly distorted;
- (iii) for chain pitting, line corrosion and channel corrosion, if the total length of corrosion in any direction exceeds the circumference of the receiver, or if the depth of penetration exceeds 25% of the original wall thickness;
- (iv) for isolated pits, pits at a concentration greater than 1 per 500 sq. mm of the surface area shall be classified as area corrosion. The depth of a discrete pit which has a diameter greater than 5 mm shall not exceed 1 mm. Pits of less than 5 mm diameters shall be assessed as far as practicable to ensure that the remaining wall thickness is adequate.

Removal of rust/corrosion

9.4 (a) *Interior surface*

Should any significant corrosion be present on the inside surface of the receiver, use a suitable extension if possible, to blast clean the interior surface with either metallic grit or shot, or a mixture of both (mineral grit is not acceptable). All existing coating of paint, foreign matter and corrosion shall be removed to near white metal finish. Alternatively, rust and corrosion can be removed by other means provided a standard is maintained for the application of paint. On completion of the shot blasting process, use a suction cleaner to remove the remaining shot or grit particles and finally use a bar magnet to any residue.

(b) *Exterior surface*

Should the corrosion or rust be spread over the receiver exterior surface, all corrosion together with the entire coating of paint and foreign matter shall be removed by shot blasting or other means prior to the application of paint. Should the corroded exterior surface be localised, manual cleaning can be used, e.g. by power tool operated carborundum disc or sander followed by steel wire brushing and dusting to remove all loosened material; or tanic acid followed by plentiful supplies of clean flushing water and then dried with clean air. Recheck the exterior surface to ensure that all rust has been removed. Paint must be applied to the exterior surface within four hours after the removal of rust/corrosion. Discretion can be given to when the bare receiver is stored in a moisture free environment e.g. in an oven at temperature between 100–120 degree Celsius.

Blast Cleaning Method

- 9.5 (a) Grit blasting should be carried out in accordance with BS 5493 and the quality of blast-cleansing shall be to 2nd quality as given in BS 4232. Preference should be given to automatic systems and can be used for all type of steels. The general appearance of cleaned steel should, over the whole surface that has been shot blasted, show “etch” pattern. After the cleaning by shot blast, not more than 5% of tightly bonded scale residue of any kind should be permitted. No single 25 sq. mm area should have more than 10% of scale residue. The surface roughness amplitude should not exceed 0.1 mm nominal and the maximum abrasive size should be as specified in BS 4232 or in S.40 or G24 to BS 2451. Blast-cleaned surfaces shall not be touched by hand or otherwise contaminated.
- (b) The surface roughness amplitude, used above, is defined as the difference in vertical height between a peak and the immediately adjacent trough. The presence of an excessive number of rogue peaks i.e. isolated peaks having an amplitude equal to or greater than twice the nominal surface roughness or greater than 0.05 mm the nominal amplitude, whichever is the less, will be considered cause for rejection of the work. In general the blast cleaning should be carried out at a stage before the testing process.
- (c) Under no circumstances should the period between the blast cleaning and the application of the first coating of paint exceed 4 hours. If circumstances arise in which the interval exceeds 4 hours, the part must be blasted clean again. This process when operated manually often gives rise to the danger of injury to the eyes. In certain circumstances excessive noise will be generated. The relevant industrial safety advice must be sought and followed.

Painting

- 9.6 Prior to the painting process, ensure that the receiver surface to be painted is dry and clean to near white metal finish.

(a) *Interior painting*

Apply 1 or more coats of rust inhibitive primer and leave to dry. This can be done by conventional spray or flood coating. For the flood coating method, 1.5 to 3 litre of primer according to the size of the receiver is poured into the receiver with the outlets blanked off. Revolve the cylinder through 360 degree horizontally, if possible, and vertically in two perpendicular planes, and drain out any surplus paint. When dry, apply one or more coats of epoxy paint and leave to dry.

(b) *Exterior painting*

Apply one coat of red oxide primer onto the area to be painted and leave to dry, then apply two coats of epoxy paint, Touch-up of uncoated surface with paint is allowed, provided that the surface is dry and free of dust, dirt, grease or rust.

- (c) The coating system stated above is just for general indoor and outdoor installation. For special operation conditions such as coastal/marine atmosphere, high ambient temperature, corrosive environment, chemical splash possibility etc., the paint manufacturers should be consulted and their recommendations followed.

Painting technique

9.7 (a) *Brush application*

The painter shall use the most suitable type and size of brush or combination of them for the work in hand. There are occasions when the thickness of paint coating is specified and it is important that in such cases the painter has available a wet film thickness gauge, and from time to time checks the thickness of the coating he is applying and adjusts his application to give the required thickness. The thickness measurement must be made as soon as the paint has been brushed out evenly.

(b) *Brush operation and technique*

The paint should be evenly applied on the surface. Considerable pressure should be exerted at the early stages of application. The work should then be 'crossed' once or twice, i.e. brushed alternatively in opposite directions gradually reducing the pressure of brush until it just touches the work on the final strokes. When applying priming paints particular care must be taken to ensure that the paint is well brushed onto all joints and crevices, and lightly laid off in level area.

(c) *Spray application*

Spray may either be conventioned air spray or airless spray. Air spray application is the method of applying paints by atomizing the paint into a pre-determined spray pattern with compressed air for the purpose of coating the surface of an object.

It is necessary to have supply of clean, dry compressed air at a pressure of not less than 410 kPa and a flow rate which can readily cope with the demands of the spray gun in use. An air filter and regulator assembly, which removes oil and dirt from the compressed air as well as regulates and indicates by gauges the operating air pressure, should be fitted as near to the spraying point as possible.

Because a high flow rate of air is required to atomize the paint, a considerable amount of air turbulence is created which will carry paint particles as “overspray” to the atmosphere. It is therefore important that sufficient and proper means of air extraction should be provided or else airless spray is preferred. An exception may be considered however, where water based emulsion paints are being used. Skilful gun control and adjustment of air pressure can reduce the “spray fog” considerably.

(d) *Spray operation and technique*

When operating a spray gun, the stroke should normally be applied by moving the gun held at right angles to the work at a distance of about 200 mm. The stroke should be straight and even across the work piece in such a way that the spray pattern overlaps the previous stroke by 50%. The motion of the gun should normally be horizontal, but may be vertical as the shape of the work dictated. As quality of finish depends largely on strict control of the spray pressure, paint viscosity, size and angle of spray gun orifice etc., operation details as suggested by the manufacturers should be followed.

Removal of grease and dust

- 9.8 Grease and dirt can be removed by water-rinsable degreasing solvents, followed by thorough rinsing with clean water. If an air receiver requires interior cleaning before further examination, this can be done by pouring a solution of detergent Teepol and warm water in a ratio of 1:10 at temperature of 40-50 degree Celsius. The mixture is prepared before pouring into the receiver and filled to about 1/5 of the total capacity. Seal all ports and rotate the receiver horizontally, where possible, about the centre axis so that all grease and dirt are removed by the flushing action. Rinse the receiver with clear water. If no sign of damage or corrosion is found, proceed with accumulation test and hydraulic test.

SECTION 10 RECORDS

10.1 The owner of each air receiver should maintain a record to enable the condition of the receiver and its fitness for further operation to be properly assessed, and to ensure any repairs or modifications to be carried out safely.

The records should include as necessary the following items:–

- (i) records of the original design and construction;
- (i i) copies of the documents required by the Regulations;
- (i i i) records of the examination reports issued by the Appointed Examiner;
- (i v) records of the operation and scheduled maintenance of the air receiver; and
- (v) records of repairs replacement, and modifications ever done to the air receiver, its fittings and attachments.

10.2 ENQUIRIES AND COMPLAINTS

If you wish to enquire about this Guide or other matters, such as the application for registration, safe operation of air receivers, approved list of appointed examiners etc., please contact the Boilers and Pressure Vessels Division of the Labour Department through:

Telephone : 3107 3458
Fax : 2517 6853
E-mail : enquiry@labour.gov.hk

Information on the services offered by the Labour Department and on major labour legislation is also available on our website at <http://www.labour.gov.hk>.

For details on the services offered by the Occupational Safety & Health Council, please call 2739 9000.

If you have any complaints about unsafe workplaces and practices, please call the Labour Department's occupational safety and health complaint hotline at 2542 2172. All complaints will be treated in the strictest confidence.

