FOREIGN COMPRESSOR EQUIPMENT SAFETY REQUIREMENTS

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There has recently been a noticeable international increase in interest regarding worker and environmental safety. It is now one of the most important factors determining the competitiveness of industrial equipment in the international market.

An analysis of international safety standards show that several of these appear, as a rule, only as recommendations. However, traditionally, the requirements in these standards are fully carried out in the production of equipment. Consequently, a study and systematization of foreign standards in the field of worker and environmental safety is a task that would not only benefit the level of safety in our domestic industry, but would also, to a definite degree, increase our international competitiveness.

A systematization of foreign material in the field of piston compressor engineering has been carried out at the Leningrad Scientific-Research Institute of the Chemical Machine Building Industry for a number of years. In this article we examine the safety requirements contained in the standards of the leading foreign industrial nations for piston compressors, and we present recommendations for their use.

The complete set of safety requirements is contained in the international standard ISO 5388 "Stationary Air Compressors. Operational and Safety Codes." The standard was developed by an international standard organization and has been approved by seventeen members of the organization including France, Great Britain, FRG, and Sweden. The national standards NFE 5l-290 of France, and BS 6244 of Great Britain are identical to standard ISO 5388. However, it should be kept in mind that the standard has not been approved by the USA and South Africa for technical reasons.

The specific dangers which arise due to design and construction errors, and due to operational mistakes of air compressors are examined in detail. These include: incorrect lubrication; improper cooling; mechanical accidents; maintenance of personal safety; the effects of noise on personnel; explosions in systems operating at high pressures; explosions in the housing; and incorrect setup, operation, and maintenance.

The majority of the contents of these standards correspond to domestic standards or, at least do not contradict them. Several of the requirements in the foreign standards are significantly stricter than those found in domestic standards. For example, in agreement with standard ISO 5388, manometers having a housing diameter of more than 63 mm to be used to measure pressures greater than 1 MPa should be placed in a protective housing having unbreakable glass and a bleed hole. At the same time, domestic codes require similar protection at a pressure greater than 10 MPa. Long years of practice using manometers in domestic compressors has shown that at a working pressure greater than 10 MPa, the chance of an industrial accident due to failure of the manometer is extremely rare.

The ISO 5388 standard contains requirements and recommendations which do not exist in domestic standards. These requirements and recommendations would increase the safety level and serviceability of piston compressors. Thus the design of values and their placement should be such that it would not be possible to set the suction valve at the pressure valve or vice versa. In the design of hollow pistons, one should ensure that the residual pressurized air is released before disassembly of the rod. In the housings of large compressors, one should consider the installation of safety equipment (membranes) which would protect the housing from failure in the case of an oil vapor explosion. The housing breather acts as the safety device in the designs of domestic compressors.

The operational instructions should include a rule which forbids opening of the cover and hatch for up to 15 min after compressor shutdown in order to avoid oil vapor explosions.

It is recommended that carbon deposits should be removed from the internal walls of the vessels and pipes which are heated to temperatures higher than 80°C. In this context, it is recommended that as a function of the operating pressure, the allowable thickness of the carbon deposits should be: at $p \leq 1$ MPa $\delta = 3$ mm; at $1 < p \leq 3$ MPa $\delta = 2$ mm, and at $3 < p \leq 5$ MPa $\delta = 1$ mm. The carbon deposit thickness is to be measured at prescribed locations of the vessels and pipes when they are opened according to a set inspection and repair regime.

When a heating system is used on the oil tanks, the heater should have a maximum energy dissipation of 25 kW/m². Pipe bundles which are positioned horizontally or pipes which must have an inspection access, should be protected in such a manner that they support a vertical load of 1.5 kN without bending or damage. Compressors which are combined with drivers that operate at variable rotational speed, should be equipped with rotational regulators in order to avoid speeds which exceed allowable values.

In the case of compressors which operate in the presence of explosive and/or toxic gases, it is recommended that one use USA standards ANSI/ASME B 19.3-1986 and API-618/86 in addition to standard ISO 5388.

Standard ANSI/ASME B 19.3-1986 was developed by the American Institute of Standards (ANSI) and American Society of Mechanical Engineers (ASME) for compressors used in the petroleum and chemical industries. The standards contain recommendations which warn against compressor damage due to excessive operational pressures, and also against the explosion and leakage of toxic substances.

As a protective device to prevent excessive operating pressures, the standard recommends the use of spring safety valves and puncture membranes, both separately and in combination with each other. The standard states that protection from excessive pressures is considered sufficient if, during operation of the safety valve, the pressure on the weakest element does not exceed 10% of the maximum allowable working pressure. A similar requirement is given in ISO 5388. However, according to domestic standards [2-6], this requirement only applies at a working pressure greater than 6 MPa. It is being proposed to eliminate this contradiction in review of current domestic standards [3-5].

The standard thoroughly examines the safety requirements of compressor equipment used for oxygen and acetylene. It is recommended that the maximum flow rate of oxygen in the tubes should be a function of the temperature, pressure, and tube material. Thus, for dry oxygen at a pressure of 1035 kPa and a temperature of 120°C, the safe flow rate in carbon and corrosion-resistant steels should be 30 and 6 m/sec respectively. At higher operating temperatures or pressures, the maximum flow rate should be lowered.

In order to avoid explosions in acetylene compressor equipment, the standard recommends that the following temperatures as functions of pressure be used:

<table>
<thead>
<tr>
<th>Temperature, °C</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>320</th>
<th>360</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure, kPa</td>
<td>2760</td>
<td>2070</td>
<td>1380</td>
<td>690</td>
<td>345</td>
<td>100</td>
</tr>
</tbody>
</table>

The USA standard API-618/86 "Piston Compressors for Petroleum Processing" has been developed by the American Petroleum Institute (API). According to the standard, compressor design should ensure a rapid change of valves and gaskets. The discharge temperature in the stages should not exceed 150°C. In order to avoid dangers due to rotational vibrations, the standard states that the natural frequency of rotational vibration in the system driver-compressor should not be more than 10% less than the rotational frequency of the shaft, and by only ±5% differ from the twofold rotational frequency of the shaft. In domestic compressor design the natural frequency of the rotational vibration is within the range of 40 to 60% of the interval between the neighboring lower harmonics which, to a large degree, ensures the safe operation of compressor machinery.

In compressors with a horizontal positioning of the cylinders, the pressurized tubes should be placed below in order to avoid fluid accumulation in the cylinders during compression of saturated gases. Staged pistons and cylinders in tandem can only be used in agreement with the client. Elongation of the rod under working conditions should not exceed 0.00015 mm per mm of the piston stroke.