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Compressed Air Systems

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INTRODUCTION

Compressed air systems are required in almost all industries such as oil and gas, chemical and petrochemical plants, agro-chem plants, power plants, nuclear facilities, pulp and paper, food, pharmaceuticals, automotive, aerospace, IT/PC industry, industrial manufacturing, large commercial buildings, hospitals, R&D facilities, and so on. The size and scope of the system depends on the type of facility. Hydrocarbon processing facilities have very large air systems with complex configurations.

Compressed air is used as motive force and for utility purposes. Dry air is required for operating control valves, on/off valves, and similar devices that cannot tolerate moisture. Air is typically dried by passing it over beds of silica gel or alumina. The beds are regenerated using source air, and moisture laden air is discharged to atmosphere. If the plant requires nitrogen, the compressed air system can provide the necessary air to separate nitrogen from the air. Some nitrogen generating systems have their own air compressors independent of the general compressed air system.

The main objective for a compressed air system is that it must continuously and reliably provide dry instrument air. While some units in the plant can be down for planned or unplanned reasons, the instrument air supply from the compressed air system must run all the time. If the instrument air system fails, the entire plant comes down. Although it is infrequent that someone worries about efficient operation of the air systems, one must remember that the air systems typically have big compressors running that use a considerable amount of power that can affect the plant economics. While not much can be done to improve the efficiency of the compressors, proper maintenance of the machines can save significant operating costs and prolong the machine life.

AN IDEAL AIR SYSTEM

When a plant is built or when a major expansion is completed, the overall air system should work flawlessly. It will have a set of air compressors including one or more spares, air receiver(s), air dryer(s), dry air distribution system, and a "wet" air distribution system that includes main headers and laterals going to the units and users. The key element of the distribution scheme is, of course, the guarantee of instrument air (IA) supply. This is accomplished by a simple pressure control scheme which shuts off air supply to non-essential air users to ensure that the normal or unexpected high demand of IA is satisfied first.

In smaller applications and in many chemical plants, ALL of the air is dried and supplied to the users through two headers. Sometimes, only a single header supplies all the air needs.

Upcoming Training Courses

- *API 936 Refractory Inspection*

  January 31-February 2, 2017
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For more information, see our website at www.carmagen.com.

Work Highlights

FCCU

- *Supported several successful FCCU start-ups onsite at multiple locations.*

Materials

- *Provided materials engineering consulting in a legal matter that involved failure of gas turbine blades.*

Mechanical

- *Provided conceptual mechanical sketches for two coke transfer lines between major pressure vessels that are part of a high temperature process being developed by a third party. Work included specification of refractory versus bare wall design, preliminary specification of insulation requirements, pipe thickness and metallurgy, connections types, and overall assessment of mechanical feasibility of the design.*

Process

- *Provided technical support to a foreign company to investigate bio-mass product gas utilization development opportunities.*

AN ACTUAL REAL LIFE AIR SYSTEM

A real air system, of course, may not come close to an ideal one. Air system problems can be attributed to insufficient pressure, insufficient flow, hydraulic bottlenecks, maldistribution, lack of proper control scheme, leakages to atmosphere, failure to maintain compressors, and dryers. As plants get expanded on a small or large scale, the air systems do not get adequately expanded. The older the plant is, the likelihood that it is more complex and less efficient increases. For illustration, here are some things that have gone wrong before:

1. As plant expansions take place, more air systems are added and are scattered around in the plant. There are multiple models of air compressors in the plant.
2. The system is overloaded, and all the compressors are running continuously with no spare available.
3. Intermittent users are overlooked or ignored during design.
4. Nitrogen back-up was installed for emergency only, but is now relied upon heavily – a real financial burden.
5. An additional air dryer needs to be installed, but there is no plot place available where the air compressors are located.
6. The moisture analyzer in the system gives alarms frequently, which the operators have learned to ignore, or the analyzer has stopped functioning altogether.
7. Cooling water supply pressure at one of the air after-coolers is so low that the hot water cannot be returned to the cooling tower and has to be disposed of otherwise.
8. At least one compressor has always given problems and is not counted upon to operate for a reasonable time. At the same time, an air compressor rented initially for three months has been in service for the last two years.
9. Some distant parts of the plant do not get the air at sufficient pressure.
10. Multiple expansions have resulted in hydraulic bottlenecks in the distribution system.
11. There are numerous jump-overs between the dry and wet air systems. Many of these do not appear on any drawings, and only one or two people in the plant know where they are and when they need to be used. And guess what, both of these guys are very close to retirement.
12. Many dry air users are getting wet air, possibly due to leakages from the jump-overs.
13. The last time anybody tried to do a comprehensive study and balance on the air system was many years ago. Nobody knows if the study was completed, if a report was ever made, and what the conclusions were. If the report was ever made, nobody seems to find an electronic or hard copy of the report. None of the people who were involved with that study can be tracked down.
14. The plant is contemplating a medium sized expansion. An EPC firm has been contracted to do an estimate. The firm obviously does not know if your existing plant has surplus air capacity. To be on the safe side, you advise them to assume that there is no surplus capacity. So the EPC firm includes the cost of a modest sized air system in their estimate. The overall project estimate comes too high. It is decided to drop the air system from the project. The project proceeds and at the start-up, they find that there is not enough air in the plant. None of the earlier discussions and decisions on the air system were properly documented. The task of explaining to higher management what went wrong and why is not easy or enviable, nor in addition to that, having to consider a very expensive solution of providing the necessary air capacity under an "emergency, right now" situation. It is not uncommon for a multi-million dollar project to have the start-up delayed because one or more utilities are not ready in time or not available in sufficient capacity.

ADDITIONAL OBSERVATIONS

Recently, three different reports were produced by a client in-house and by third parties on an air system failure. The air system failure had resulted in large quantities of expensive refrigerant being released to flare in an LNG plant. In addition, there was production loss. There was another unrelated air failure a few days later and the same losses were repeated. Such plants have emergency depressuring valves that open upon emergency situations. They first isolate affected systems and then immediately release pressure from the system to minimize damage from a fire or some other emergencies. These valves have to be FO (fail open upon loss of air). However, the valves need to stay closed and not open inadvertently. The valve actuators are provided with volume bottles or surge tanks with two dissimilar check valves in the inlet line. Should there be an air failure or leak elsewhere, the bottles will continue to maintain the air pressure and the depressuring valves will continue to maintain their intended closed position. All reports concluded that numerous check valves were missing. So when the small failure/leak occurred elsewhere, the bottles lost their air pressure to the leak resulting in the valves opening and discharging large quantities of refrigerant to flare and shutting down the LNG train on low pressure.

Why were so many of the check valves missing? The volume bottles, associated check valves, and piping were not shown on the project P&IDs. They were shown on instrument detail drawings. Here is the problem. When the plant is mechanically completed, a walk-down is performed by the contractor and/or the owner to ensure that everything is installed correctly as intended by the engineering team. Only then will the owner take care, custody, and control of the system/plant. If any component is not on the P&ID, its installation may not get verified and the owner may have accepted the plant with potential deficiencies.

WHAT CARMAGEN CONSULTANTS CAN DO FOR YOU

We can survey your system, interview plant personnel, agree on a basis, and later develop a package with necessary documents and drawings that describe your system. Information from this package can be used by the plant personnel in daily operation and in the future. It can also be used by outside parties for future expansions or other air system related issues. With changes in plant ownerships being so common, it is good to have up-to-date and proper information about all systems.

If you are considering process expansion, air system addition needs to be evaluated. In the initial stages, you may need to estimate what that requirement will be. We can assist you, and propose how the new air system will integrate with your existing system.

About the Authors

Bob Shah has over 35 years of experience in process and project engineering, with extensive focus on offsites, utilities, and power generation. He is considered an expert in utility systems, including compressed air systems. He is also experienced in Upstream and Offshore facilities, LNG Terminals, and vaporization facilities.

Jerry Lacatena has over 35 years of process engineering experience in a broad range of design applications and technologies. He is a proficient and organized multi-tasker, having extensive plant design experience on numerous revamp and grassroots projects throughout the world, with projects ranging from feasibility studies, technology evaluation, FEED, EPC development, to plant performance testing. Jerry has excellent presentation, communication, coordination, and interpersonal skills utilized to develop strong working relationships with team members, clients, vendors, sub-contractors, and technical licensors.

Please contact Jerry Lacatena, Process Department Manager (jlacatena@carmagen.com) if you'd like more information on Carmagen's expertise in this area. Carmagen Engineering, Inc. is an engineering consulting company with experienced staff that can support clients' efforts associated with utilities and offsites requirements.