OPERATIONAL EXPERIENCE OF COMPRESSED AIR SYSTEM FOR LARGE ACCELERATOR COMPLEX

Sanjay Chouksey, S.K. Suhane, S.S. Parihar, Gurnam Singh
Raja Ramanna Centre for Advanced Technology, Indore (MP) 452013

Abstract

Operation of various devices in Indus-1 & Indus-2 synchrotron radiation sources requires uninterrupted supply of instrument quality compressed air. For this purpose, a centralised compressed air system was commissioned in May 2005 and is operational on round the clock basis. Instrumentation was done for air quality monitoring at various stages of distribution. Availability and reliability of the system was analysed based on the failure data. In Year 2008, compressed air system was upgraded to improve the reliability.

In this paper, we present design philosophy, fabrication, installation, instrumentation, testing and availability of the compressed air system in Indus complex.

INTRODUCTION

Indus Accelerator Complex comprises of two Synchrotron Radiation Sources (SRS) namely Indus-1 and Indus-2 with maximum electron beam energy being 450 MeV and 2.5 GeV respectively [1]. Various devices along transport lines (TL-2 & TL-3), storage rings and user beamlines of Indus-1 & Indus-2 require Instrument quality compressed air for their operation. A centralised compressed air system has been designed and installed to supply the compressed air with varying requirement at the user end.

DESIGN PHILOSPHY

Flow rate, pressure, air quality and duty cycle are the important considerations for designing a compressed air system. Devices of Indus subsystems require uninterrupted (high reliability) supply of Instrumentation quality, dry, oil free and particle free air as per DIN ISO 8573-1[2] standard. The important uses of compressed air are actuation and control of pneumatic valves and cylinders for vacuum valves, safety shutters, cooling of the components and operation of air bearings for beam line experimental stations. The Indus compressed air system is designed to maintain air quality of Class 2.4.3(ISO 8573) with particle size<1 micron; Pressure Dew Point (PDP): 3^{o}C and oil content <1 mg/m^3. The pressure required for these devices varies from 2 to 6.5 Kg/cm^2 with flow rate requirement of 0-100 litre/min. The Indus machine subsystem devices with respective air requirements are listed in the table 1.

SYSTEM DESCRIPTION

The system comprises a screw compressor (FAD 1m^3/min capacity, 10Kg/cm^2), refrigerated air dryers (PDP of 3^{o}C) to remove the moisture of the air, particulate filters (5 micron), oil filters and 1000 liters capacity air receiver. The air is distributed from receiver to the end users through 1 inch nominal size piping (stainless steel grade AISI304). Piping network is mostly dictated by the machine and components layout. Total length of piping is about 200 meters in ring area, 70 meters in TL-3 and 160 meters in experimental hall. Total 52 nos. of outlets are provided to distribute the air with a lever operated ball valve of ½ inch NB at every outlet to control the airflow. Entire SS piping with fittings were TIG welded and hydro tested at 15bar. All the threaded joints were soap bubble tested to detect any leakage of compressed air.

Table 1: Indus components and subsystem with compressed air requirements

Name	**Location in the machine with Nos.**	Pressure /flow/ ***Quality requirement***
RF shielded UHV Gate Valves	Equi-spaced along the ring (10)	~ 6 bar ***(MF/F/I)***
Pneumatic actuators on Beam Profile Monitors	Storage ring & Transport lines (19)	4 - 6 bar ***(MF/F/I)***
RF cavity input power coupler cooling RF cavity cooling rack	Indus-2 RF cavity (Ring area) RF power supply area	0.5- 2 bar/20 lpm ***(MF/OF/C)*** 6 bar/ 1 m^3/hr ***(MF/OF/C)***
Pneumatically controlled gate valves and safety shutters	Front end and beamline (10 per beam line X 27)	~ 6 bar ***(MF/F/I)***
Transport line-3 beam shutter	TL-2 end (1)	~5 bar **(MF/F/I)**
Air bearing for beam line exp. stations	Beamline Exp. Station(4)	0.5-2 bar / 25 lpm ***(MF/F/OF/C)***
Operation of mobile radiation shielding plug door	Opening from Indus-1 – Indus-2 (Near TL-3)	2-3 bar ***(MF/F/I)***
F- Filtered; **MF**- Moisture free; **OF**- Oil free **I**- Intermittent; **C**- Continuous flow		

PREVENTIVE MAINTENANCE

Compressor is working in automatic mode on round the clock basis within 6.5 kg/cm^2 (cut-in) & 7.5 kg/cm^2 (cut-out) pressure limits.

Periodic maintenance of the compressor unit is done as per the checklist provided by the manufacturer. Compressed airline from receiver through ring area and experimental hall is checked periodically on weekly basis to locate any leakages or other faults. Moisture drain taps are provided at many locations throughout the piping network. These taps are checked once in a month and moisture collected, if any, is drained out by opening the manually operated valves.

RELIABILITY & SAFETY

Daily log of the compressed air system is maintained since commissioning of the system in May 2005. Availability and failure rate were assessed based on these data and a case study was performed [3] in Year 2008. Main causes of failures are air leakages, electrical power and compressor unit.

Air receiver has been provided with safety valve which will not allow pressure increase beyond 10 % above the working pressure when the air compressor is giving full output and all outlets other than safety valve are closed. Hydrostatic leak testing of all the piping systems was done at 150% of design pressure, to safeguard against possible failure at normal working pressure. Temperature, pressure and over current interlocks are provided in the compressor unit [4].

SYSTEM UPGRADATION

Based on the case study, system was upgraded for higher reliability, redundancy, stable pressure control, better air quality and low operation cost. Additional screw compressor of higher capacity (Free Air Delivery (FAD) of 2.5 m3/min) was installed for the redundancy. Power is supplied through UPS for un-interrupted operation. To stabilize the system pressure, lower leaks and less compressor run time, additional air receiver of 1000 litre was installed (Fig.1). Timer based condensate drain valve was installed. A timer system is fitted with the compressor unit to prevent over run of motor. Desiccant type moisture separator was put for additional moisture removal. One-micron size particulate filter and charcoal type filter for oil removal have been added. After up gradation, average reliability of the compressed air system is higher than 99.5%.

INSTRUMENTAION

Pressure transmitters have been provided at various locations in the machine. The digital signal of the pressure is displayed on PC console in control room. Over pressure and under pressure alarm signals are provided in the control room so that operator can take necessary action. All the pressure readings and alarm signals are recorded in the data server of the control room. A mimic panel of compressor status and a control box with power-reset button is installed near control room for quick restart of the compressor unit by the operation crew.

CONCLUSION

Process design, plan layout, preventive maintenance, quality assurance during fabrication and installation play vital role in failure rate and system availability. Air quality and availability of the compressed air system is ensured by scheduled maintenance. There is further scope of system modification/ upgradation.

The authors are grateful to Shri C.K. Pithawa, Head Electronics Division, BARC for his useful suggestions and support in implementation of upgraded system in year 2008.

REFERENCES

[1] Technical report of synchrotron radiation source, Indus-2 (Pub Sep 1998)

[2] www.iso.org International organization standardization (ISO 8573)

[3] "Case study of compressed air system, Indus complex", one day Workshop on Reliability of Complex Engineering Systems, OCT 15,2008, RRCAT Indore

[4] Indus-2 Safety Report, (p41-43, clause7.3.0)

Figure 1: Layout of compressed air system Indus complex after upgradation