PRECISE TEMPERATURE CONTROL & CALIBRATION OF ALIGNMENT INSTRUEMENTS FOR INDUS II

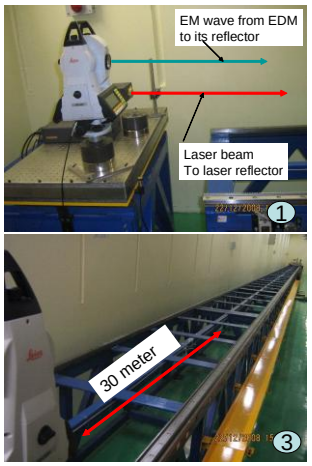
Deepak Arzare, R K Sahu, R P Agrawal, S S Kulkarni, Gurnam Singh
Raja Ramanna Centre for Advanced Technology, Indore, India

Abstract

Survey and alignment plays an important role in building and operating accelerator machines since it is essential for keeping the beam on designed trajectory over large distances. In Indus-2 magnets are aligned at their positions in horizontal plane using theodolites integrated with electromagnetic distance meters (EDM), Distinvar™, Levels etc. All such instruments need to be calibrated periodically to ensure greatest possible accuracy. A new distance calibration facility with laser interferometer as primary standard has been setup at RRCAT which demands precise temperature control and uniformity within ± 0.5° C, along the 30 meter long travel of laser beam over the calibration bench. The year-round conducive stable environment for the installed calibration facility was achieved with a cost economic- energy efficient system air conditioning system instead of customised high value PID controlled systems. This paper describes precise temperature control system commissioned at 30 meter long calibration facility along with laser interferometer based calibration results.

CALIBRATION FACILITY

The calibration bench is essentially a 3-axis CNC table of large range of X movement and very small range of Y-Z movement. It is equipped with a laser interferometer at one end which provides a standard for distance measurement. A motorized carriage provides movement to the two retro-reflectors- one aligned to EDM and another to the laser beam. System can measure and calibrate distance upto 30 meters. Fig.-1 shows the general arrangement of the calibration bench.



1. EDM integrated in Theodolite and Laser interferometer mounted on a fixed Table at one end
2. Carriage with reflectors
3. Linear motion system for 30 meter carriage movement

Figure 1 : General arrangement of the calibration bench in different views.

AIR CONDITIONING SYSTEMS FOR TEMPERATURE CONTROL

Standard comfort air conditioning systems precisely operates within ± 2.0° C of temperatures using set point control. Design of air conditioning system for better accuracies and precision (~ ± 0.5° C) and that too along a 30 meter long calibration table was learnt to be a challenge. Conventionally such systems are customised as close loop system using algorithms with PID controllers and attract very high capital costs. We have achieved such stable environment using standard available comfort air conditioning systems by careful planning & design within defined budgets. The facility has been planned as 30M long partially underground tunnel to minimize fluctuating solar gains and also assuring north lighting.

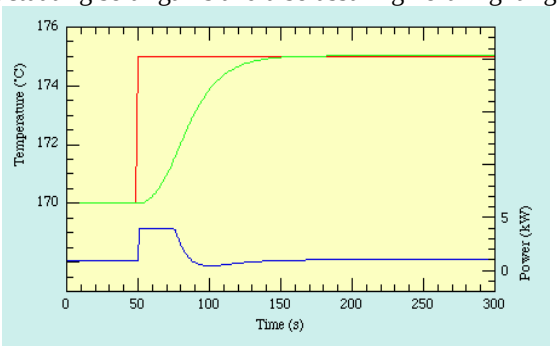


Figure 2: PID Temperature control

The stringent temperature control is achieved by simulated detailed flow dynamics ensuring proper air flow patterns, avoiding dead air pockets and to maintain uniformity of the system throughout the year. The careful selection of air distribution architecture is one of the important design paradigm.

Variable Volume Systems

The detailed study revealed that such precise control of temperature can be possible with either of

1) Variable Air volume (VAV) System
2) Variable Refrigerant Volume (VRV) Systems

VAV systems are ducted systems with variable frequency driven (VFD) motorized dampers to control the air flow as per close loop feedback, however they need lot of space above false ceiling for equipment installation and have limitations such as EMI, minimum comfort velocities and reheat issues. Variable Refrigerant Flow (VRV) systems[1] eliminates these limitations & thus planned to meet the objectives. It is a No-Duct system, working on the principle of varying refrigerant flow to individual evaporative units by refrigerant piping as per actual loads and simultaneously adjusting the capacity of

master digital compressor. The new age electronic refrigerant expansion valves modulate refrigerant flows through refnuts with modulated 3 sensor programmed inputs using microprocessor and thus cooling/heating is achieved as per microprocessor inputs. The digital scroll compressors with 20 second load/unload cycle time & step-less capacity modulation makes VRV to qualify.

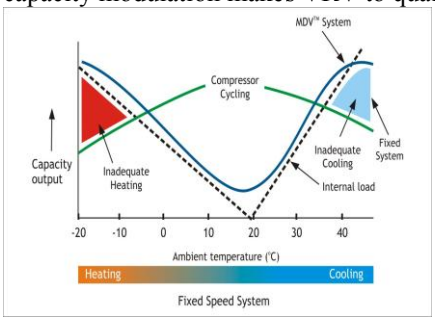


Figure 3: *Load matching curves for Conventional and Digital Compressors*

SUBSYSTEMS

The building blocks of the complete system includes outdoor units consisting digital scroll compressors, modulating multi-way refrigerant control valve, Four-way supply cassette indoor units with in built electronic refrigerant expansion valves, and connecting refrigerant liquid/gas and condensate piping, Ref Nuts, fresh air ports along with Zonal control monitors (ZCM). Digital compressor based units have been used instead of Inverter compressors, to avoid harmonics interferences. It has excellent part- loading capabilities (up to 10%) due to 4way valve.

Salient features of the complete systems are as follows:

Parameter	Value
• Outdoor Unit	Air Cooled Digital Scroll Compressor with stepless (10%) Modulation 20.8 TR (2 Nos)
• Indoor Units	Four way cassette indoor units 2TR x 09 Nos
• Refrigerant Network & Monitoring	Refrigerant liquid/gas and condensate piping, Electronic expansion valves, Ref Nuts, make up air, pt100 sensors with accuracy of 0.15°C
• Zonal Control Monitors	BMS interface & close loop control wiring

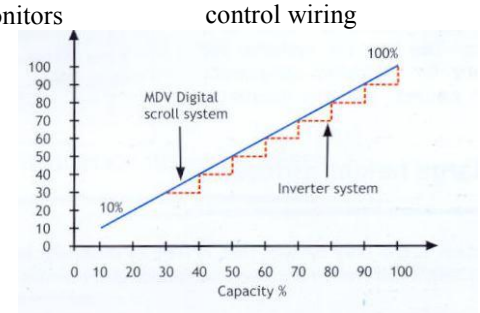


Figure 4: Energy Savings with Stepless Modulation

Figure 5: Calibration Lab with Ceiling Supply Air Units

CALIBRATION OF EDM

The commissioned Distance calibration facility is used to determine the zero and cyclic errors of EDM instrument–reflector pairs. Instrument prism is moved along the bench and distances are measured by the EDM to be calibrated and then are compared with interferometer distances measured simultaneously. The result is a calibration curve. A Fourier series can model this calibration curve and it is found that residuals with respect to a modelled curve are generally less than 0.1 mm. This curve is used to correct measured distances.

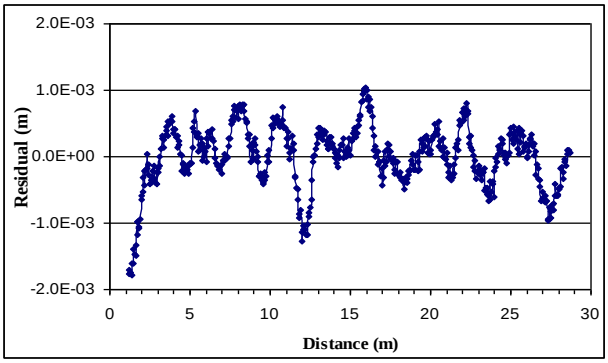


Figure 6 : Residual after linear regression of measured distance

CONCLUSION

The complete system has been installed, tested and commissioned. Temperature stability of ± 0.5 deg C has been achieved successfully along & over 30M long calibration bench during all seasons. The supervisory and control system has been installed having BMS compatibility and thus complete system is accessed & controlled from the PC desktop thru RS 232 port.

ACKNOWLEDGEMENTS

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REFERENCES

[1] A Practical Guide to Multi-split Systems and Variable Refrigerant Volume (VRV) Systems by Mike Hardy