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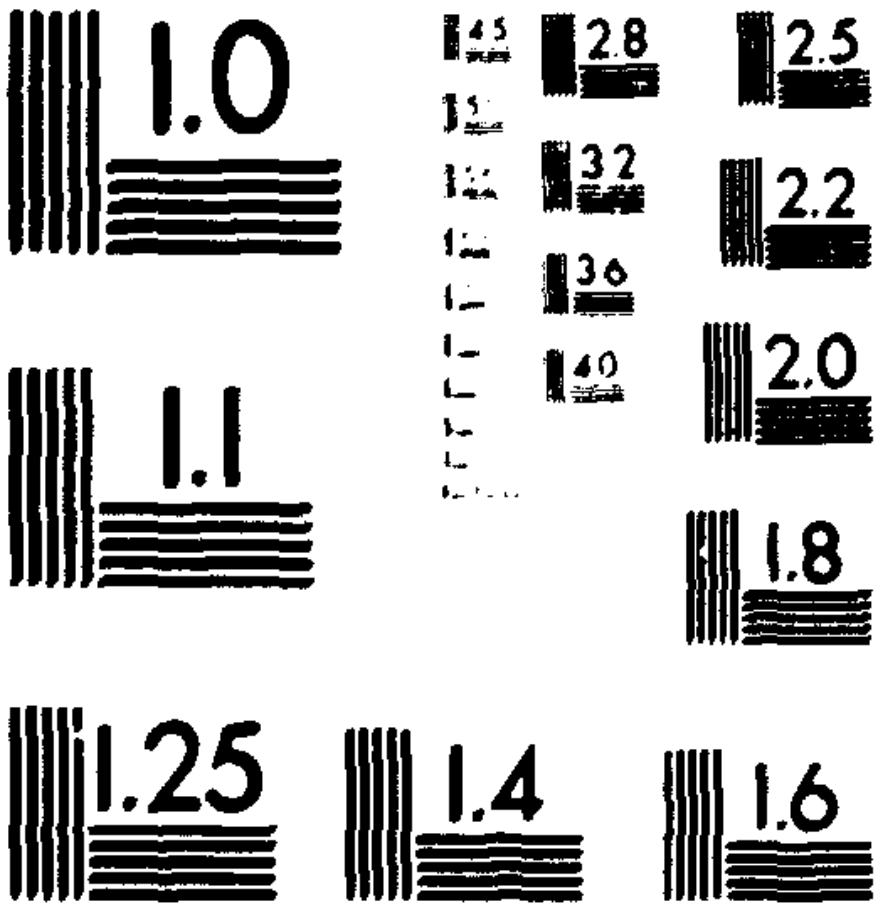

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

India.

VACUUM STANDARDS.

DP/IND/79/004

REPUBLIC OF INDIA

1985

Final Report*

Prepared for the Republic of India by the
United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Anita CALCATELLI,
Expert in the field of Vacuum Standards
with special reference to Mass Spectrometry
(mission: 29 October - 24 November 1984)

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TABLE OF CONTENTS

UNIDO Final Report

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Consultant to : Pressure and vacuum section
National Physical Laboratory (NPL)
New Delhi, INDIA

Subject: Erection and commissioning of laboratory equipment related to primary vacuum standards
(Jop description DP/IND/79/007/11-03/31.3.N)

Period : - Departure Torino 3.30 pm on 27/10/1984
Arrival New Delhi 9.05 am on 28/10/1984

- Departure New Delhi 10.25 am on 25/11/1984
Arrival Torino 10.30 pm on 26/11/1984
(after debriefing in Vienna - UNDP offices)

- Worked at N.P.L. from 29/10/1984 to 24/11/1984 inclusive, except holidays

1. Introduction

The pressure and vacuum section is equipped with the following vacuum systems:

a) dynamic system of gas expansion for calibrating ion gages (fully assembled)
b) static expansion system for calibrating vacuum gages (including thermal conductivity gages) (partially assembled)
c) ultra-high vacuum system equipped with turbomolecular and titanium sublimation pumps, awaiting installation and commissioning to which a quadrupole mass spectrometer (already purchased) can be fitted
d) ultra-high vacuum device equipped with ion and titanium sublimation pumps in which a LEED-Auger system (not yet received) will be incorporated.

All these systems have been either bought from abroad or built from imported components using ultra-high vacuum technology.

All the equipments enable to perform research at present international level in the field of vacuum physics and metrology, for that they will require only few modifications, extensions or improvements which will be suggested by the increasing experience.

My main working field has been connected to the dynamic system since it was already assembled and it needed to be characterized from the metrological point of view.

No difficulties have been encountered in working either with Dr. J.K.N. Sharma or his colleagues, who were always as cooperative as possible and

open to gain the greatest benefit from my stay at NPL.

The relatively small amount of difficulties has been the same as the Indian colleagues are forced to face every day, for example lack of specialized workers at intermediate technical level for supporting research staff, lack of ultra-high vacuum components at NPL and, more generally, in India etc.

In spite of the fact that political circumstances have forced the NPL laboratories to be closed for two or three days the scheduled tests have been performed by increasing the activity during the following days in agreement with the colleagues.

During my stay a PhD thesis of Dr. R. Sharma has been examined and a written report has been submitted to the Dean of the faculty of pure Sciences at the Indian Institute of Technology, in New Delhi.

2. Work done

For what concerns the dynamic systems for ion gages calibration the following problems have been considered and fully or partially solved, in cooperation with Pradeep Nohan:

1) temperature measurements of all the significant parts
2) measurements of the effective pumping speed and tentative evaluation of the accuracy
3) measurements of the gas throughput at varying pressure (and constant volume) and tentative evaluation of the accuracy
4) evaluation of the metrological limits of the method 3) at low and high pressure
5) measurements of the gas throughput at varying volume and constant pressure
6) evaluation of the limits of the method 5) in the present geometrical configuration and possible improvements
7) tentative evaluation of the accuracy of the method 5) and comparison between the two different methods of measuring the flow.

The dynamic system, at present, can be used to calibrate ion gages in the pressure range 5×10^{-5} ÷ 1×10^{-3} mbar with an accuracy less than ± 10% using the gas throughput measurement method based on constant volume and varying pressure. This accuracy value is still improving.
An extension of the pressure range has been possible only with few modifications measuring the gas throughput by the method of varying volume and constant pressure. In this last case it is, hereafter, possible to calibrate ion gages from 2×10^{-6} to 1×10^{-3} mbar with a total accuracy between ±2 and ± 10% depending on the value of the pressure.

The dynamic determination of the pressure is strongly depending on the gas throughput measurements which have to be improved from the point of view of the geometry and the materials and components, as it has been discusset with the colleague Pradeep Mohan.

Very little time could be devoted to the mass spectrometry since the greatest part of it had to be spent in working on the dynamic system to be used for calibrating iongages. Since during my stay I would like to see the quadrupol mass spectrometer working my task has been to assist A.C. Gupta, D.R. Sharma and Dr. Chakraborty in connecting this sensor to one of the volumes of the static expansion system (which is pumped down by one

diffusion pump and hy an ion pump) and in trying to start the quadrupole. Now this mass spectrometer is working well, the only diffuclty is connected to the use of a computer which has been installed in the laboratory but one interface has not been yet delivered.

3. General remarks

The colleagues of NPL working in the vacuum field have some difficulties:

- in their country it is quite difficult to find industries able to make ultra-high vacuum systems and components which are necessary in the pressure range covered by the systems (see part I) which have all been built with such technique which guaranties good vacuum conditions;
- since the laboratory is quite young from the metrological point of view the metrological aproach to the problems is gradually improving with the experience and the researchers there are quite open to this particular aspect and procedures necessary in this kind of work;
- accessory for ultra-high vacuum systems (as for axemple gate valves, sets of valves, gaskets and schrews, adapators for various conflat flanges etc) are in general not available;
- it is necessary to improve the mechanical components built at NPL, or they have to be manufactured by workshops specialized in the ultra-high vacuum technology;
- many parts of the primary calibration systems need to be characterized in the best way mainly for what concerns the dimensions, that requires cooperation with other NPL laboratories (as for example lenght section) to have the value of the accuracy which can be basically achieved;
- the secondary pressure gages which are used in the flow measurements have to be calibrated with a primary system (such as ultrasound U tube manometer or piston gage) for accuracy and flow computation;
- laboratories must be improved on the following aspects:
  - temperature stability
  - continuity of supplying electrical power (it will be usefull to have an emergency generator)
  - continuity of cooling water flow for the diffusion pumps and turbomolecular (it should be usefull to have a forced closed water circuit).

  If these last two items will be accomplished the pumps could be on for long periods so there will be a significant improvement in the ultimate pressure and in the cleanliness of the vacuum systems.

4. Conclusions

To have the possibility of working with some researchers of the NPL has been stimulating since they have a good beckground in physics and they are open to cooperate. This condition has permittet to accomplish a considerable amount of work in the relatively short periode of four weeks.

The UNIDO program has given to the vacuum and pressure section the opportunity of getting good instruments in the field of vacuum metrology and physics and it is desirable that UNIDO will continue to support Indian researchers giving them the possibility to complete the laboratory

instrumentation on the basis of the wider experience gained at home and abroad.

It is also necessary to give scientists, after a period of experience at home, the opportunity of stay in specialized laboratories to improve the metrological treatments of the problems from various points of view, as for example evaluation of factor influencing errors and to get abituated to the use of compact electronic instrumentation, and computers.

It is very important that the young scientists have financial support for partecipating in the international conferences, that is usefull for being less isolated and more self confident.

For what concerns new instruments I want to suggest: a stainless steel flowmeter to be operated at varying volume and constant pressure. It could be built by an european manufacturer (specialized in ultra-high vacuum techniques):

- one or two control and measurements units with linearized output for ion gage operation;
- electronic instruments, as multimeters directely interfaced to computers (by bus IEE 488 for example);
- at least one personal computer and related accessories (as bus IEE 488, monitor, printer, diskdriver, etc).

For what concernes instruments and equipments received under UNIDO assistence some of them, more sofisticated, can not be fully utilized since they have develped foults and need repair, it is recommended that a good number of spare parts be purchesed and assistence be provided by the manufacturers in the form of contract for another two or three years, including the installation and the maintenance.
The UNIDO may consider this point and provide the necessary funding for the same.

For what concernes the system for surface analysis not yet delivered, it seem quite complete; it will be necessary to add only few components to fully complete Auger-LEED apparatus with CMA analyser without making too complicated the system, while the equipment with turbomolecular pump (see c) part. I) could eventually fit an ion gun for SIMS analysis of materials. In this way the section could have a complete set of instruments usefull to characterize materials.

In conclusion I feel that my stay at NPL has been frutfull for the advancement of the project and I suggest an extension of it particularly giving the possibility to the Indian scientists, working in the vacuum physics and metrology, to stay in other metrological laboratories (as for example IMGC, Italy) to perform a research program, for example, to computerize dynamic expansion system and to study surfaces by ultra-high vacuum analitical techniques.

UNIDO should continue to support such exchange of scientists through the project "vacuum standards" for few more years.