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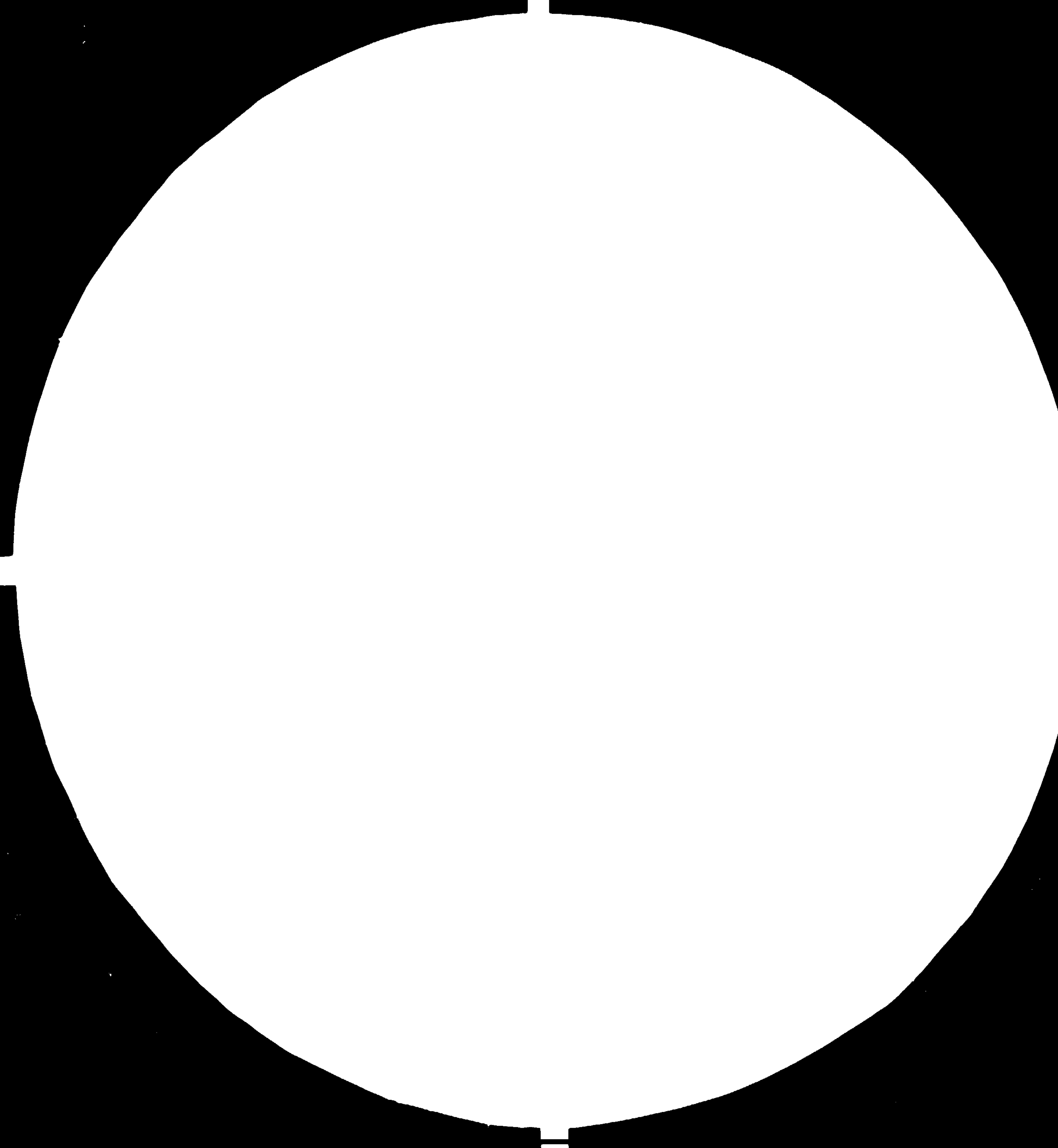

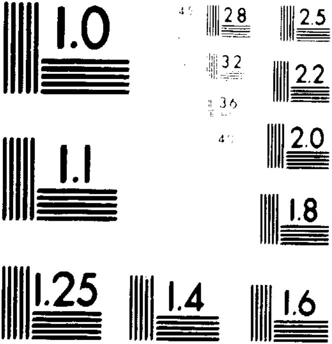

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DP/ID/SER.B/408
1 July 1983
English

India. ESTABLISHMENT OF A FLUID CONTROL RESEARCH INSTITUTE (PHASE 1)

DP/IND/81/030

INDIA

Terminal report*

Prepared for the Government of India by the
United Nations Industrial Development Organization, acting as
executing agency for the United Nations Development Programme

Based on the work of P. Harrison, C.Eng., M.I.Mech.E.
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Vienna

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Abstract

The mission report describes the work of the adviser during a nominally three month long contract in advising on the setting up of a fluid control research centre at Palghat, Kerala in India. After an introduction showing the need for the centre in the context of the rapid growth of industry in India, the report deals with the mission background, and official arrangements, before passing on to describe an initial tour of the research institutions of India designed to establish what facilities in the flow measurement and control field already existed. The report confirms the inadequacy of such facilities. A study tour of selected research institutions of developed countries with Indian national specialists is described. A discussion of the findings of the tour show that over a period of many years developed countries had found it necessary to invest heavily in specialised research facilities and equipment to achieve progress in the design of their products. The adviser describes the design of the project and preparation of the project document in which he assisted, and in a discussion of it elaborates, justifies and explains the decisions made and the choices available to the authors. The report concludes with a list of findings on the mission.

Two annexures detail the study tour itinerary and give the individual visit reports of the tour.

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INTRODUCTION

The industrialisation of India is progressing rapidly. The growth of the steel, coal and cement industries, of power generation, and of the chemical and petrochemical based industries within the country, involves the introduction of industrial processes which are growing in complexity as the national quest for increased efficiency intensifies and the need for energy conservation becomes more urgent.

Problems of measurement and control occur in all processes and on their solution the economics of the process usually depend. Of the control and measurement of the physical parameters of temperature, pH, viscosity, time, etc vital to industrial processes, flow is a parameter whose overall importance may be recognised, but because of its complexities, is little understood.

Flow measurement and control problems are regularly being encountered in India by, among other industries, the valve industry and by process control instrumentation companies. Because a centralised and coordinated source of expertise in this discipline and the necessary specialised research, development and test facilities are not available in India, progress towards self-sufficienty in the design of products associated with flow control or measurement is severely hampered. The Indian Government have been made aware of this problem and are prepared to create a Research Institute to assist the industries concerned. In turn, the Government is seeking assistance and guidance from the UNDP in establishing such a research centre. No coordinated previous work has been done in this field nor has financial assistance been previously requested for it.

Mission background

The Government of India approached UNDP to seek assistance and guidance in the setting up of a Fluid Control Research Institute. The assistance envisaged under this first phase of the project will fulfil the basic requirement of the preparation of a document for the full scale project with a UNDP input of $2.2 million, which is included in the Extended CP-II.

The details of the assistance requested are given in Project Document (Phase 1) IND/81/030/A/01/37) but maybe summarised as follows.

To provide an adviser on the setting up of a Fluid Control Research Institute (see Job Description DP/IND/81/030/11-01/31.I.D) whose duties would be:

a to assess the growing needs of the fluid control and measuring instruments industry in India, and to report.

b to advise and take part with national specialists, in a study tour of developed countries to study the role of such Fluid Control Research Institutes and assess the state of the art in the relevant fields of research and the facilities and equipment available in those countries.

c to assist in the preparation of the project document for the establishment of the Institute by the study team.

d to prepare a final report setting out the findings of the study tour and his mission.

The following mission report by the adviser is in fulfilment of requirement (d) listed above.

Official arrangements

The Project Document and Job Description were approved by UNDP in May 1982. The adviser was recruited in the latter half of 1982. The special service agreement (Expert on Mission) was dated 10 January 1983 (Index No E-530352) with a termination date of 9 April 1983. This was twice extended at the request of the counterpart and changed from one continuous mission to a split mission, the adviser returning home after the Indian assessment tour and before commencing the study tour with the study team. Further, at the end of the study tour at the request of the counterpart the adviser returned hom to spend two weeks collecting technical information, catalogues , quotations and estimates for the equipment and research facilities for the future Institute before returning to India with this information to assist in the preparation of the (Phase 2) project document. The dates of the mission were thus 10 January-1 February 1983 and 26 February-25 May 1983.

I. REPORT ON THE MISSION

The adviser flew to Vienna on 10 January 1983 to spend two days at the UNIDO headquarters there to be briefed on his mission, prior to flying to New Delhi, India on 13 January to meet the UNDP officials responsible for the project in New Delhi and the national specialists from Instrumentation Ltd who were to take part in the study tour. The role of Instrumentation Ltd which is a nationalised Indian company and who are to be the government implementing agency for the project is referred to in the Phase 1 project document.

Two days were spent in New Delhi preparing an agreed list of laboratories that the team should aim to visit on the study tour. Correspondence between the adviser and the team on this topic had already been exchanged and a tentative tour itinerary was prepared which was subsequently amended and revised by the counterpart as acceptances or refusals for the proposed visits by the host organisations were received. Much of the arrangements were made by Telex and the final itinerary was submitted to UNDP and UNIDO for approval, and for ticket issue etc.

The adviser had arrived in India expecting to work for the duration of his mission on a continuous basis. However it was clear that the study tour would take some time to organise and approve, and UNDP New Delhi were persuaded by the counterpart that the adviser should firstly spend some time in India making an assessment of the needs and requirements of industry for the proposed research centre and reporting his findings. He should then return hom via Vienna to report the changed arrangements for his mission to UNIDO and stay at home until such time as all preparations for the study tour had been completed. The adviser could accommodate the change in plans by slight modifications to existing commitments and it was agreed.

Before his arrival in India the counterpart had made arrangements for the adviser to visit Indian Research Institutions to determine what expertise and facilities are available that might be relevant to industrial problems in the field of flow measurement and control.

On the morning of 16 January 1983 therefore, the adviser in company with V K Ramakrishnan a national specialist of the study team, commenced a series of visits to Indian research centres. The visits are described in the following section.

A. The needs of the fluid control and flow measurement industries of India

As given in the Job Description the first task of the adviser was to make an assessment of "the needs of the fluid control and measuring instruments industry in India". During the ensuing ten days of visits and discussions,clarification and refinement of the objectives of this task was made, and the more specific aim was pursued of determining how well India was provided with the relevant expertise and research facilities, what more was needed to tackle the research requirementsof industries involved in the field of flow measurement and control, and to determine what those requirements are.

It was clear that in the time available, a comprehensive or definitive assessment was impossible; the visits in the main were confined to research institutions, and apart from discussions with the staff of Instrumentation Ltd at their valve factory at Palghat talks with other manufacturers were not possible. However it was possible to obtain a broad picture of the situation, and it is unlikely that a more widespread investigation would seriously modify the conclusions reached.

At the end of the series of visits a period of two days in New Delhi was used to write a technical report (DP/ID/SER.A/428 28 February 1983) and discuss its contents with UNDP officials and the study team.

The findings of the technical report may be summarised as follows:

a The Indian valve industry is or will be faced with technical problems inherent in the development of the new or expanded range of products required by the process industries and the scope of these problems is given in the report. Assistance in the form of a centralised, coordinated source of expertise having the necessary research and development facilities is not available to it in India.

b The, as yet,small flow measuring instruments industry or the much larger group of flow meter users, in India have no flow meter calibration facilities or source of flow measurement expertise available to them.

c Some specialised facilities and information on topics relevant to the problems of the valve industry exist in the research institutions of India, but its availability is not known to those who could best use it. Much more could be done immediately and before the proposed Research Institute becomes operational to improve the transfer to industry of the technology that is already available.

The report thus confirms the inadequacy of the research expertise and facilities available in India in the field of flow measurement and control, as predicted in the Phase 1 project document.

B. Study tour by national specialists and adviser

A study group of three Indian national specialists:

Wing Commander A K Dhingra, Group Leader
Mr R G Kini
Mr V K Ramakrishnan

and the UNIDO adviser:

Mr P Harrison

visited selected research institutions, valve test facilities in factories, and flow metering companies in Japan, USA, UK, Sweden, Netherlands, France, Germany and Switzerland, between 28 February and 8 April 1983. The group had a two day briefing at UNIDO Vienna at the end of the tour.

The visit and travel itinerary is given as Annexure 1, and the individual visit reports are included as Annexure 2.

As far as possible each visit was structured so that in addition to seeing and discussing the test facilities and equipment with the staff of the host organisation, which was the prime purpose of most visits, time was given to exploring together the possibilities of establishing future bilateral technical cooperation and the training of Indian staff by them. The opportunity was also taken to study the methods of laying down and developing the research programmes of the organisation and the merits and otherwise of the organisational structure adopted. In particular, aspects of research staff motivation and career building were studied, and where appropriate the linkages between research institutions and industry were examined.

The developed countries have invested heavily over a period of thirty to forty years in specialised test and development facilities in the flow control and flow measurement field. In some cases, as was to be seen in Japan and to a lesser extent in the UK, national research facilities have been created. In the USA, on the other hand, equally comprehensive facilities have been provided by individual companies for their own research and development programmes, leading to the duplication of facilities within one country. The investment in these facilities has been seen to be a worthwhile, if not essential expenditure, in order to develop the products that customers require, and the finance to pay for these, in some cases extremely sophisticated facilities, has had to be found. Rarely has it been found possible to have the work done in university laboratories since universities are not usually equipped to cope with industrial size problems. Size, in all cases, is seen to be the major limiting factor, but many organisations have decided to invest heavily in building test facilities capable of calibrating their largest size flowmeter, or performing the seismic test requirements on their large valves. These facilities were viewed as essential if their new products were to be developed and sold.

The individual visit reports in Annexure 2 indicate where training of Indian staff is a possibility and/or where bilaterial technical cooperation might be arranged. It would appear that training in specific techniques, such as noise measurement and analysis, or in valve testing (C_v) or flow meter calibration, may be possible at the research laboratories of a number of companies and in some research institutions. Some organisations have said that it would be necessary to charge for the training given. Many of the organisations have never been asked for this sort of help before, and whilst agreeing in principle, negotiations for, and the mechanics of, the training would have to be worked out ab-initio and without the benefit of previous experience. One or two organisations run training schemes for their customer's staff and some take in foreign students on a regular basis. It would seem that with careful negotiation and planning by UNDP/UNIDO and the Indian implementing agency it should be possible for sufficient training places to be found for the relatively large number of Indian 'students' envisaged.

The question of bilaterial technical cooperation proved to be a more difficult matter to resolved. The fact that the Indian specialists of the study group were employees of a valve manufacturing company was reason for the study team to be viewed with suspicion when visiting companies who manufactured valves. Not surprisingly, companies were hesitant of discussing problems, and disclosing organisational or technical matters to possible commercial competitors. In some cases it took a long time for the team to allay the distrust of the host, in other cases they failed to do so and the visit was of limited value, or it was ultimately cancelled. On the other hand, where Instrumentation Ltd already had licensing agreements, in fact or in prospect, with the manufacturers visited, it was necessary to emphasise that the study group were acting on behalf of UNIDO to formulate a national research facility and not for Instrumentation Ltd. The difficulty here was to determine how company based research programmes could be related to the research programmes of a developing national research centre without becoming involved in problems of commercial confidentiality. The adviser is of the opinion, that whilst this may be possible in specific instances, it would be better to cultivate and maintain the contacts already made, and negotiate bilaterial cooperation at a later stage in the evolution of the Indian research centre.

Technical cooperation with national research organisations was found to be a more promising possibility than with manufacturers,although only three such organisations were visited. The National Engineering Laboratory in the United Kingdom for example is, in the flow measurement and control field, running on a parallel course to that proposed for the Indian research centre, and with no language problems to hinder communication it would appear most desirable to foster the contacts and understandings made during the two day visit of the study group to that organisation. The contacts made with NRLM in Japan, and Gaz de France in Paris should not be neglected and although perhaps more difficult to organise it should be possible to conclude with both these organisations, cooperation on limited but specific topics of mutual concern.

The study group, in considering the topic of the development of research programmes, again had to distinguish between the requirements of manufacturer's laboratories, and those of the national research laboratories. Manufacturer's programmes were almost invariably product orientated and were formulated within the company through consultation with product managers, heads of laboratories and management; in some cases on an ad hoc basis, and in others, more formally through a research programme committee.

The national research laboratories tended to have a more complex and formalised machinery for evolving their research programmes, used the services of industrialists and academics to serve on an advisory board in conjunction with their own specialists, and through the work of international standardising committees were organised to play their part in internationally sponsored research programmes.

The functional organisation of the work of the laboratories visited, was of great interest to the study group. The problem of ensuring a clear line of responsibility, and a career and promotion structure (usually achieved by employing the traditional vertical organisation of staff) on the one hand, and on the other hand, finding means of ensuring that specialists in different disciplines could be organised to work together to solve multi-disciplinary problems (usually achieved by using a horizontal staff organisation) was well recognised and understood. No entirely satisfactory matrix organisation that combined vertical and horizontal management structures appears to have been evolved. Most managers believed that a vertical structure had to be maintained to ensure good motivation, control, and career prospects for the research staff, and preferred to achieve horizontal linkages by spending time themselves on ensuring that where multi-disciplinry organisation is needed, it is supervised and progressed at the highest level, and in the simplest possible manner.

During the study tour the team considered the concept of the research centre to be built at Palghat and bearing in mind what it had seen, began to formulate the basic requirements for it. To begin with a list of possible reseach activities was drawn up and their relative importance considered, subsequently a list of the test facilities and equipment needed for the agreed research activities was compiled. Sketch designs of the major test facilities were made and the main components listed. A tentative organisational structure of the 'family tree' type was sketched out.

At the end of the tour, with the team at UNIDO Vienna, the formulation of the project document was discussed and the study group leader requested that before moving on to India to help draft the project document, the adviser should return home for two weeks to obtain as much information in the form of prices, specifications etc for the equipment for the new laboratory as possible. It was felt that much of this information was not readily available in India, yet it was essential to have it, if the cost estimates to be prepared for the project document were to be realistic. An extension to the adviser's special service agreement was arranged at UNIDO, the Indian national specialists returned to India, and the adviser went home to commence the task of amassing the necessary information.

C. Preparation of the project document

The adviser returned to India on 30 April 1983, taking with him the information obtained, spent a few hours at UNDP New Delhi and then travelled to the Kota works of Instrumentation Ltd where his colleagues of the study tour were preparing to start work on the design of the project and the writing of the project document.

The total cost of the proposed test facilities and equipment was estimated, and this was found to be in excess of the total budget allocated by UNDP to the project. A choice of the essential facilities and equipment was made therefore, and the laboratory floor areas necessary to contain the facilities were estimated. From a knowledge of the floor areas an approximate estimate of cost for the laboratory buildings was calculated, to which was added the cost of offices etc to house the scientific and administrative staff etc.

Estimates of the cost of training staff were made, and the requirements for specialist advisers determined. Several revisions of the estimates were necessary before an acceptable balance between the equipment and training components of the UNDP total budget figure of $2.2 x 10^6$ could be achieved.

Using other project documents as models, the various sections of the project document were drafted and revised after discussion.

A first draft of the project document with its many annexures was assembled on 17 May and after some last minute revisions taken to New Delhi overnight on 18 May. The UNDP staff studied the document, and at a meeting on 20 May with the study group a series of modifications to the document were agreed. Whilst this involved substantial alterations to the presentation of the project and a lengthening of the time scale for construction, the basic concept of the research centre as originally proposed remained substantially unaltered. It was agreed that these modifications to the project document should be made by the Indian national specialists, and a revised document prepared by the middle of June 1983.

On his return to Vienna on 21 May the Adviser took with him a copy of the first draft project document to hand to the UNIDO staff for study and comment. This document of course did not contain the modifications agreed between the study group and the UNDP on 20 May.

At a debriefing meeting on 24 May the adviser discussed the project document and itemized the modifications requested by UNDP.

D. Mission Final Report

On his arrival in New Delhi on 19 May the adviser had had no opportunity of preparing a final report on his mission. The UNDP staff explained that after submission, no progress on the routing of the project document through acceptance procedures could be made without an accompanying mission final report. The adviser estimated that it would take three weeks after his return home to draft a final report on his mission, however he undertook to prepare an outline report within 24 hours. A manuscript version was submitted to UNDP on the morning of 20 May which was subsequently typed and checked during that day.

Copies of this outline report were retained by UNDP New Delhi, the counterpart, and a copy was submitted by the adviser to UNIDO Vienna on his return there for debriefing. Valuable suggestions by UNIDO staff were made on the recommended contents of the mission report. The adviser commenced work on the report on 30 May and completed drafting on 15 June. It is hoped to send the type master of the report to UNIDO Vienna by 17 June.

II. DISCUSSION AND FINDINGS OF THE MISSION

The Phase 1 and 2 project documents and the introduction to this mission final report have sought to show that with the rapid industrialisation of India, technical problems associated with the development of new products and equipment are occurring.

In the flow measurement and control field, research facilities and expertise to solve such problems have been shown to be largely absent, and the Indian government propose to build a specialised research centre at Palghat, Kerala, to remedy this insufficiency.

Technical problems in developing countries can be solved in either of two ways:

a If the solution exists in a developed country it can be obtained by buying the solution, - usually in the form of licensing agreements to manufacture products, the design and materials of construction of which embody the solution to the technical problem encountered. An example of this might be the negotiation of a license to manufacture a valve, the internal shape of which has been designed to minimise pressure loss across the valve, or the materials chosen to be cavitation resistant. Both high pressure loss and cavitation resistance are technical problems currently facing the Indian valve industry.

b To attempt to solve the problems within the country and without external assistance.

Whilst there are advantages and disadvantages in adopting the first course, if the second alternative is adopted, it can only be successful if the means to investigate the problems in the shape of research facilities and expertise are available. (It may also be observed, perhaps somewhat cynically, that the availability of facilities and expertise in themselves is no guarantee of the solution to technical problems.)

Research facilities and expertise can be deployed by one company for its own use, but in a developing country this is not a good use of scarce economic resources, and some method of centralised or national deployment of them, would seem to be the wiser course to adopt.

Taking a long term view there is a clear need and justification for the research centre proposed.

It is difficult for the adviser to comment very knowledgeably on the choice of the Palghat site for the location of the research centre, for whilst the advantages of the Palghat site are known to him the merits of alternative sites are not. However it can be argued that in a rapidly developing country the size of Europe, and with its connections with South East Asia, a site for the research centre in the industrial south of the country, is a logical choice. The site chosen would seem to be very suitable, has been carefully considered, and matters concerning the availability of power, acccessibility to road and air transport networks, and the availability of adequate communications have been satisfactorily resolved. Its nearness to the Instrumentation Ltd factory at Palghat has advantages in that the former has available logistical support in the form of shared housing, medical facilities, shops, community centre etc for staff. There can be no doubt that the research centre's proximity to a long term potential customer, should ensure a variety of practical problems for it to solve which should avoid any tendency of the centre sinking into academic introspection.

A prime concern of the UNDP in allocating funds to a project is the adequacy of the government appointed implementing agency to carry out its task. Initially the adviser was in some doubt about this matter and discussions during the study tour did not dispel them. However a wide range of expertise was made available at Instrumentation Ltd Kota to assist in the drafting of the project document and if this same expertise or its equivalent is available to the implementing agency during the project implementation phase at Palghat there should be no problem, particularly if, as envisaged, the specialist advisers called for in the project document are made available.

In the technical report "An assessment of the needs of the fluid control and flow measurement industries of India" already referred to in section IA of this report, the point was made that in the time available a comprehensive survey of the needs of these industries was not possible. The adviser believes that such an assessment should be a continuing process that is never completed, and one vital to the healthy development of the research centre. For that reason he views the function of technical marketing as having a status as important as any of the scientific or technical functions in the organisational structure of the centre, and requiring knowledgeable, technically qualified staff with a good knowledge of Indian industry, to fulfil that function. To enlarge on this matter somewhat, it would appear essential that that function should have a two-way traffic,with marketing managers constantly in the field, determining the problems and requirements of the industries the research centre aims to serve, and by means of publications, lectures, seminars, correspondence and visits making sure that the work and results of research at the centre reaches the audience that can benefit from it. It cannot be emphasised too strongly that the primary aim of the centre would be to carry our industrial research, and this highlights the need for strong industrial, rather than academic representation on both the Governing Council, and the Research Requirements Board of the centre, and that strong linkages with industry must be guaranteed by the organisational structure of the research centre.

Turning now to a discussion of the design of the project, an examination of the proposed research activities of the centre may be helpful in amplifying the activities section of the project document.

In the work of the research centre it will be important to strike a balance between work for the valve industry and work for industries that use flow measurement, (methods or meters) as an essential item in their processes. Whilst initially because of the influence of Instrumentation Ltd in the organisation of the centre, many of the demands on it will stem from the problems of the Indian valve industry and Instrumentation Ltd in particular, it is important that the organisation, facilities and equipment of the centre should also be capable of coping with the demands of flow meter users and manufacturers that will surely grow as the facilities become known and the status of the centre becomes assured. In the fields of hydromechanics and hydrodynamic research there are fortunately large common areas between the problems of the valve and flow measurement industries, and both water and air research facilities have been designed that can be used equally well for valve or flow measurement research.

It is proposed that the following scientific/technical disciplines should be instituted at the centre and that these would cover the known research needs of the industries for the immediately foreseeable future:

Flow measurement and control - liquids and gases
Materials - metallurgical and cavitation problems
Noise, stress and vibration
Theoretical hydromechanics and mathematics - systems and modelling
- statistics and computation
Instrumentation and measurement - electronics - physical standards

Reference may be made to the table on Page 3 of the technical report "An assessment of needs ---- etc" previously referred to, which lists the known problem areas of the Indian valve industry for example, and it will be seen that the five disciplines listed above encompass all the problem areas given in the table. During the life time of the project it is expected to set up the five scientific/technical departments in the research centre, specialising in these disciplines, provide a sufficiency of staff trained abroad to fit them for their roles in the organisation of the centre, and provide the departments with the necessary facilities and equipment to enable an agreed programme of research and testing to commence.

Much of the facilities and equipment is of non-indigenous origin and would be provided from the UNDP budget allocated to the project. Some comments on the proposals are indicated.

The project document (Annexure IV et seq) distinguishes between test facilities and equipment. Test facilities are pieces of research apparatus, - in most cases, large, complex and expensive, which are specifically designed and constructed for their range of duties. Whilst they may utilise standard items of equipment in their construction, they are not themselves standard items readily available from a manufacturer's catalogue. They are itemised separately in the project document because each facility will have to be designed, constructed, installed and commissioned either as separate 'turn-key' projects or as a group of 'turn key' projects.

The study group in its tour spent much time studying the design and construction of these special test facilities in the various laboratories they visited. As already discussed in the description of the study tour (section IB) the developed countries have considered it necessary to invest in these expensive test facilities. The budget for the whole research centre is inadequate to begin to match the facilities available elsewhere and the study group have had to decide after considerable discussion with many experts at the various laboratories visited, what essential test facilities affordable within the budget should be provided, and how this requirement should be balanced against the scientific and test equipment also needed to equip the laboratories. In the event the test facilities were reduced to three in number, one using water and housed in its own laboratory building, and two smaller test facilities establishing the air test facilities for the research centre. The large water test and calibration facility was chosen to be of primary importance because it is a universal rig equally applicable for valve or flow measurement testing. All the laboratories visited had a test facility of this type and it seems to be generally agreed that it is the most frequently used research facility within the laboratory. After the provision of a water flow standard facility it was also agreed that air facilities and flow standards are of great importance and should next be catered for. The gas flow calibration facility described in Annexure IV(A_2) of the project document is to be set up to provide the absolute standard against which small air/gas meters can be calibrated, standards which as far as can be determined do not yet exist in India and which will become of increasing importance as gas pipe lining and supply grows in that country. Aerodynamic model testing is a well established technique for improving the head loss and recovery performances of valves, and the test facility described in Annexure IV(A_3) combines this model testing function with the ability to calibrate air flow meters against a transfer standard meter situated in series with the meter to be calibrated.

Noise and vibration are the source of many industrial flow and control problems. Equipment to be able to measure and analyse noise and vibration both in the industrial environment and in the laboratory is essential if progress is to be made in the development of 'quiet' valves for example. Similarly the detection of the onset of cavitation in valves or flow meters is best detected acoustically or by hydrophone. The sum proposed to be spent on noise and vibration measuring equipment is indicative of the subject's importance and is comparable with the outlay of other laboratories visited on the study tour.

The measurement of flowrate involves the measurement of volume or mass, and time. In fact in any flow measurement and control laboratory the basic physical quantities of length, volume, mass, pressure, temperature, time and frequency must be capable of being measured to a high degree of accuracy, and standards must be provided against which measuring instruments can be compared and calibrated. This is perhaps a suitable opportunity to explain that in contrast to a UNDP project involving for example the setting up of a factory or other production facility where the equipment bought with UNDP funds is in constant use creating a marketable product, in this particular project UNDP funds will be spent on buying some equipment that will be used less intensively than equipment in other projects.

The reputation of a research laboratory depends on the credibility of its results, and these results depend on the accuracy with which the test measurements are made, and so every laboratory must possess standards which are used periodically to check the accuracy of the instruments used in the test work. The standards themselves must periodically be checked against regionally or nationally held standards of higher precision, thus establishing for the measurement a 'traceability' chain relating ultimately to the international SI system standards themselves. The equipment list of Annexures IVB, 1, 2, 3 and 4 in the project document contains items which are standards necessary to establish the credibility of the measurements made at the research centre, and which will be infrequently used. For the reasons given, this equipment is none-the-less essential to the work of the centre.

Without wishing to labour the point unduly, it should also be understood that in any laboratory where equipment must be available to undertake a broad spectrum of research, the utilisation factor of the facilities and equipment is low by comparison with that expected of, for example, machine tools. Looking for a common place analogy one is reminded of the differences between the usage of a combine harvester and an ordinary farm tractor in the agricultural scene. In highly developed economies both items of equipment are necessary.

The only tangible end product of a research laboratory is a test or research report. Perhaps unfairly, judgements on the quality of the research and the status of the laboratory are made on the quality of the documentation that issues from it. Traditional printing methods are slow and expensive and the output of a busy research centre is considerable. Modern methods of offset lithography are displacing traditional printing methods in developed countries without degrading standards of quality and at a considerable reduction in cost. Annexure IVC lists the requirements for a modest modern plant sufficient for the foreseeable needs of the research centre, for equipment that is so far not available from indigenous sources.

In discussing the design of the project the proposed organisational structure of the research centre merits consideration. An organisational pattern consisting of the five technical or scientific departments already discussed and a sixth, a marketing department, forming together the scientific and technical core of the centre, and to which would be added the essential service, workshop and administrative staff, was initially proposed. In essence this has been retained in the organisational chart which appears as Annexure II of the project document, which is a structure proposed by the study group leader.

Whilst taking into consideration differences in the style of management of research in Europe and in India, the adviser believes that the organisation proposed will give no scope for career building and will limit the promotion prospects of the staff to an unacceptable degree. Although it is noted on the chart that the "organisation will undergo changes to meet changing requirements --- etc" it is suggested that the structure be reconsidered before staff recruitment commences.

During the study tour efforts were made to lay the foundations for future technical cooperation between the centre and similar research institutions in the developing countries and an outline formal understanding was concluded with the National Engineering Laboratory in the United Kingdom. The project document gives some proposals for a future programme of collaboration and looks to the possibility of links with other institutions. There can be no doubt that such cooperation will be an important factor in the development of the centre and a necessary step in the international acceptance of the new centre as a focus of flow measurement and control research in India.

The adviser has listened to many discussions on the role and functions of the proposed research centre and at least one fierce argument on a proper title for it. Throughout the project documents it is referred to as a "Fluid Control Research Institute". This does not seem to describe the functions of the centre adequately. Research into fluids will not be a primary interest of the centre and why do fluids need controlling? As a valedictory gesture may the adviser submit "Flow Measurement and Control Research Institute" as his contribution to the controversy?

Findings of the mission

The discussion in the preceding pages has resulted in the following findings being proposed.

a There is a clear need and justification for a research centre of the type and scale proposed to be situated in India.

b The site proposed for the research centre appears to be suitable and has been carefully considered.

c The government implementing agency appears to have the necessary facilities and expertise to fulfil its function. The range of additional expertise to be supplied by UNDP funded advisers and as specified in the project document should adequately supplement the work of the agency.

d The primary aim of the centre is to carry out industrial rather than academic research. There is need for strong industrial representation on the Governing Council, and the Research Requirements Board.

e In the work of the centre it will be important to strike a balance between the research requirements of the valve industry and the requirements of the flow meter users and manufacturers of India.

f The study group found that developed countries have invested heavily in sophisticated research facilities in the flow measurement and control field. To become self-sufficient in the successful design of new products, instrumentation, systems etc comparable facilities must also be made available in India.

g The equipment content of the UNDP budget for the research centre has been examined in detail and the need for it explained. By comparison with some other UNDP assisted projects much of the equipment to be provided will not be in constant use but is nevertheless essential.

h The adviser suggests that the organisational structure for the research centre as proposed in the project document should be reconsidered.

j The possibility of establishing technical cooperative ventures between the research centre and similar institutions in other countries has been explored and appears promising.

Study tour visit and travel itinerary — Annexure 1

Date 1983	Itinerary
27 Feb	Group meets in Tokyo, Japan
28	Visit to ISOGO, Yokohama. Visit Indian Embassy Tokyo
1 March	Visit Toshiba Ltd, Fuchu Works, Tokyo
2	Visit National Research Laboratory Metrology, Tsukuba Science City
3	Visit Yamatake Honeywell Ltd, Samukawa
4	Fly to Los Angeles, USA
6	Fly to Houston, USA
7	Visit WKM Ltd, Missouri City
8	Visit Cameron Iron Works Ltd, Houston
9	Visit Daniel Industries Inc, Houston
10	Visit Cameron Iron Works Ltd, Cypress, Houston. Fly to Cleveland, USA
11	Visit to Bailey Meter Co (cancelled)
13	Fly to Pittsburgh
14	Visit Rockwell International Ltd. Fly to Philadelphia
15	Visit Honeywell Inc, Fort Washington, Pa
16	Visit Yarway Corporation, Blue Bell, Pa. Fly to Boston, Ma
17	Visit Masoneilan Division, McGraw-Edison Co. Fly to London, UK
21	Visit Brown-Boveri Kent Ltd, Stonehouse, Glos
22	Visit Brown-Boveri Kent Ltd, Rotork Ltd, Bath. Fly to Glasgow
23	Visit National Engineering Laboratory, East Kilbride
24	Visit National Engineering Laboratory, East Kilbride
25	Visit to British Petroleum Ltd, Kinneil (cancelled)
27	Fly to Gothenburg, Sweden
28	Train to Saffle. Visit Eurcontrol Källe AB. Train to Gothenburg
29	Fly to Amsterdam, Netherlands. Train to Groningen. Visit Gasunie. Train to Amsterdam.

Date 1983	Itinerary
30 March	Visit to Krohne Ltd (cancelled). Fly to Paris, France
31	Visit to Electricité de France (cancelled)
1 April	Visit Gaz de France, Alfortville, Paris
4	Fly to Frankfurt AM,German Federal Republic
5	Train to Göttingen. Visit Fischer & Porter. Train to Frankfurt.
6	Fly to Zürich, Switzerland
7	Train to Winterthur. Visit Sulzer Brothers. Train to Zürich.
8	Fly to Vienna, Austria
11	Visit UNIDO, Vienna
12	Visit UNIDO, Vienna
13	Indian national specialists return to India. Adviser to UK

NOTES ON A VISIT TO ISOGO LABORATORIES, YOKOHAMA, JAPAN ON 28 FEBRUARY 1983

Address: ISOGO Engineering Laboratory
Engineering Test Centre
8th Shin-Sugita
Isogo-ku, Yokohama

Persons seen: Mr Yasuo Kajiyima, Director
Mr Kiyoshi Nakagawa, Deputy Manager

Facilities:

Purpose: The laboratories were set up to do research on valves and accessories used specifically in the nuclear power generation plants in Japan.

Brief Description:

a Loss of coolant test facilities. Primarily to study the effect of hot water on valves and accessories, mainly the latter. Water not radioactive, but at temperatures up to 150°C for PWR and 171°C for BWR. Water flashes to steam. Mainly used for testing eg plastic materials, diaphragm materials, limit switches etc.

b Rig for determination of valve C_vs. Circuit consists of an open loop having sump, circulating pump, four way taper plug valve, test section, reference orifice plates, diverter and weigh tank.

Circulating pump. Single entry centrifugal, double sided rotor 30 m H_2O head, 160 kW motor.

Test Section. Maximum diameter 400 mm (16 in).

Orifice plates. Inserted between flanges. D and D/2 taps. DP cell.

Diverter. Vertical type air operated.

Weighing machine. 5 tonne

Flow rate. 1,500 m^3/hr maximum

Diverter Operation. 0.1s

c Vibrational test facility. xyz axis one at a time. 4-5 g acceleration. Steam passed through valve on test. Stress in valve measured using strain gauges.

d Steam test section. Used for endurance testing of valves. 1000 psi, 280 ton/hour of steam, saturated or wet. Maximum valve size = 600 mm (24 in). Simulated life test = 400 reversals with motor actuator.

e Environmental Chamber. Function is to simulate thermal aging of valves in P & BWRs. Steam and water spray. Maximum teperature 184°C. Pressure 10 kg/cm^2. Volume of chamber 133 m^3. Maximum valve size on test = 600 mm (24 in). Chamber pressure 4 kg/cm^2.

f Hot water test section. Used for endurance testing of valves. 2450 psi maximum pressure. 200 ton/hour maximum flow at 650°F using a hot water circulating pump. Maximum size of valve on test = 400 mm (16 in).

g Boiler. 15 ton/hour at 189 kg/cm^2 at 395°C using a reciprocating boiler feed pump.

h Safety Valve Test Facility. Study performance of valve by varying temperature of steam. Steam gathered in accumulator and measured downstream by orifice or nozzle prior to flowing through valve on test. Escaping steam ducted to dump tank. Wetness/dryness fraction measured to correct flow rate values obtained from orifice/nozzle.

Description Literature obtained:

Nuclear Power Engineering Test Center. July 1981. ISOGO Engineering Laboratory.

NOTES ON A VISIT TO TOSHIBA ELECTROMAGNETIC FLOWMETER FACTORY AND CALIBRATION FACILITIES, TOKYO, JAPAN, 1 MARCH 1983

Address: Toshiba Corporation
13-12, Mita 3 Chome
Minato-ku, Tokyo 108
Japan

Persons seen: Mr Hiroshi Taware, Manager, Overseas Group
Instrumentation and Automation Division
Mr H Nakone, Manager, Electromagnetic Flowmeters

Facilities:

Purpose: The calibration facilities, currently the largest in the world, were set up for the production testing of magnetic flowmeters.

Brief description: Three test sections have been constructed to accommodate meter sizes up to 3 m diameter. A common sump and two service pumps serve all 3 test sections but each test section has its own dedicated diverter, weightank and weight scale. Reference meters are used in each rig and calibrated by its weightank/diverter system. In the largest rig the reference meter is calibrated up to the maximum flowrate capacity of the largest weightank, but thereafter the reference meter calibration is assumed to be an extrapolation of the lower flowrate values.

Rig capacities: maximum flow 30,000 m^3/hour

Weightanks: 40 tonne in 10 kg divisions, 5 tonne in 1 kg divisions and 1 tonne in 0.2 kg divisions.

Pumps: 2 mixed flow 15,000 m^3/hour at 10 m H_2O head electric motor fixed speed.

Reservoir: Open and external to building, 1200 m^3 volume

Descriptive Literature obtained:

a Illustrated brochure in Japanese with inserted English translation giving some information on the facilities.

b Toshiba Electromagnetic Flowmeter catalogue.

NOTES ON A VISIT TO NATIONAL RESEARCH LABORATORY OF METROLOGY, TSUKUBA SCIENCE CITY, JAPAN 2 MARCH 1983

Address: National Research Laboratory of Metrology
1-4, 1-Chome, Umezono, Sakura-Mura
Niihari-Gun
Ibaraki-Pref 305, Japan

Persons seen: Dr M Kawata, Director General
Dr Eng K Kurase, Director, Third Department
Dr K Komiya, Chief, Composition Measurement Section
Mr N Watanabe, Flow Measurement Laboratory

Facilities:

Purpose: The Laboratory serves as the Japanese national centre for standards of flow measurement and metrological research. Flow measurement is dealt with by the Fluid Metrology Division which is one of the four divisions of the third department headed by Dr Eng K Kurase.

Brief Description: At the main Laboratory facilities exist for the measurement of gas and small water flows.

In the gas flow laboratory, low pressure facilitiers bell provers, air bags (5 and 30 m^3 capacity) rootes type meters and sonic nozzles are used to calibrate a hierarchy of secondary standards, mainly wet gas meters. High pressure calibration facilities are not available.

A test rig for the pattern approval tests for small water meters has been constructed and an open channel flume using calibrated electromagnetic flowmeters to measure the flow generated by two centrifugal pumps and checked against a volumetric pipette, is available for small meter calibrations.

However important new facilities situated some 20 km north of the Main Laboratory were completed in Autumn 1981. The facility consists of a water sump of 900 m^3, a constant head tank of 144 m^3 at 23 m height and four pipelines of 400, 650, 900 and 1100 mm in diameter and having a straight pipe length greater than 100 diameters. The flowrate covers up to 3000 m^3/hr and is generated by 7 identical constant speed centrifugal pumps.
The flow standards are a weightank 50 tonne and diverter
b volumetric burette 10 m^3 and diverter

One of the uses of this facility is the calibration of large size orifice plates which are widely used in many industries. Facilities cost 700×10^6 Yen ie £1.9×10^6.

Descriptive literature obtained and relevant references:

NRLM in Tsukuba Science City. Metrologia 18, 45-46 (1982) Springer-Verlag.
Pamphlet describing Organisation, Personnel, Special Projects, basic researches, publications, research expenses in 1982.
Pamphlet describing organisation and activities.
Family tree etc.

Brochure "AIST Tsukuba Research Centre".
Brochure describing in Japanese Tsukuba Research Centre No 2 ie the new facilities.

Reference: Komiya, Watanabe, Takamoto. Report of Conference at Kanagowa University. Japanese Society of Mechanical Engineers No 830-4 1983. March 31-April 2. Paper No 912 (In Japanese).

NOTES ON A VISIT TO THE FACTORY OF YAMATAKE-HONEYWELL CO LTD, SAMUKAWA, TOKYO, JAPAN ON 3 MARCH 1983

Address: Yamatake-Honeywell Co Ltd
500 Ohmagari, Samukawa-machi
Kohza-gun, Kanagawa-ken
Japan
Tel: (0467) 74-2111

Persons seen: Mr Shozo Kitazawa, General Manager
Mr Toru Takahashi, Production Manager
Mr Morinobu Kobayashi, Manager (Palghat-Samukawa Project)
Mr Hideo Satow, First International Department Marketing and Sales

Facilities:

Purpose: The test faciiities exist to calibrate the product range of magnetic flowmeters manufactured by the company. Valve C_v test facilities also exist, but are of similar design to the IL Palghat plant.

Brief Description: The circuit drawing of the magnetic flowmeter calibration facilities is enclosed. Two variable speed centrifugal pumps individually controlled, pump the water from an underground sump to a header tank 15 m above ground level, the tank holds somewhat less than 50 tonne of water and the level is crudely controlled by level sensors regulating the pumps. The pumps are more precisely regulated by the setting of the downstream control valves. Eight test lines in two banks of four are supplied by two downcomer pipes from the head tank. Test line size range = 6-600 mm. Each bank of test lines is manifolded into a pipe leading a flow control valve (butterfly type), diverter (oil hydraulically operated, with photo-electric timing switch) and weigh tank (2 and 20 tonne Yamoto). Each weightank is emptied in to a pit, where the water is pumped back to the sump by small pumps. A branch line returns flow to the sump just upstream of each rig control valve, the branch has its own flow control valve. Customers can choose to have their flowmeters calibrated either by the use of the weightanks or by the use of a reference meter placed in series with and downstream of the meter on test. In the case of the latter alternative the flow is diverted through the branch line and does not flow through the diverter and weightank leg of the circuit. The reference meters are calibrated against the weightank at monthly intervals, and the weighing machines themselves are calibrated against dead weights, annually by the government officials. All controls and test measurement readouts are situated on a central control panel. Readouts are fed to a programmable calculator and print out, and the calibration results are printed out automatically on to a standard printed sheet. Maximum flow rates are not known but the two pumps are of 18.5 kW at 200 V each and together will probably produce a maximum flow of 0.2 m^3/s.

Descriptive Literature obtained:

Magnew Square Wave excited electromagnetic flowmeters No CA2-561 (issue 2) - Yamatake Honeywell.

NOTES ON A VISIT TO W-K-M LTD, HOUSTON, TEXAS, USA ON 7 MARCH 1983

Address: ACF Industries Incorporated
W-K-M International Operations
16500 South Main
Missourie City
Texas, USA

Persons seen: Mr W R Hochmuth, PE International Sales Manager
Mr J Wilson

Facilities: The company manufacture gate and ball valves only and the test facilities were created to develop their present range of products and to do routine testing of the valves to customer and/or national specifications.

Brief Description: The larger facilities were grouped in an open area partly covered but having a strong concrete floor. A free standing prefabricated cabin is used for the test team and the necessary instrumentation.

Blowdown rig. Used to test the adequacy of design of soft seat valves, a large cylindrical reservoir of water terminates at one end in the valve under test. Large pipes connect the upper portion of the reservoir to accumulators holding large volumes of compressed air. As the valve on test is opened to its maximum extent the compressed air forces the water through the valve at high pressure and velocity. Since large volumes of compressed air are stored the pressure drops relatively slowly so that the velocity of water through the valve does not diminish appreciably as the valve opens. A few minutes flow of water (which is just ejected to waste) is then followed by a lengthy pause whilst the CA accumulators are charged by the compressors.

Bend test rig. A long railway flat car supports at its end a section of pipe with a valve fitted into the pipe at the mid point. Two hydraulic rams attached to collars situated either side of the valve on test are used to impose a downwards bending load on the pipe, and strain gauges are fitted over the valve body to determine the stresses and deformation. The valve is test actuated to determine that it will still function under bending conditions.

Fire safe rig. The standard test codes demand that certain refinery ball valves shall be tested to ensure that in the event of fire the absence of the soft seating and packing when destroyed by heat shall not permit a significant outward leakage of fuel to feed the flames. The fire screens and enclosure to contain the valve etc were in the open and isolated from other test facilities.

Hydrostatic test rigs. Of conventional design but necessarily large to accommodate the largest size valve. The holding jigs were of their own design. A pneumatic test with the body immersed in water always follows the hydrostatic test.

Cold Rig. Now dismantled the company had a cold chamber which was used to reduce the temperature of the valve to Arctic conditions and the valve was opened and closed to check that it would operate correctly when installed in the Alaska pipeline.

C_v tests. Since only on/off valves are manufactured the company has not provided itself with a water flow test rig. For their product range the C_v tests were contracted out to Rice University 25 years ago.

Literature obtained: None.

NOTES ON A VISIT TO CAMERON IRON WORKS INC, HOUSTON, TEXAS, USA ON TUESDAY 8 MARCH 1983

Address: Cameron Iron Works Inc
PO Box 1212
Houston, Texas 77251
USA

Persons seen: Mr D C Dunn, Administrative Assistant
Mr W J Richardson, Technical Marketing Representative Ball Valve Division
Mr B L Ross, Technical Training Instructor (Brookshire Training Centre)

Facilities:

Purpose: Many of the test and research functions of the organisation are required because of the increasingly stringent environmental conditions in which valves for the oil-well industry are expected to function. Whilst standard documents for valves exist, many companies insist on highly specialised materials and finishes and regulated methods of production, and send in their own inspectors to supervise the quality control of the products they buy.

Detailed Description: Much of the visit was taken up with an examination of the newly built special products centre and of the ball valve factory.

The former, in which every item is inspected, tested and certified at every stage in production, has a range of sophisticated measuring gear including a programmable automatic 3 axis measuring machine. Gamma ray and x-ray test facilities, magnetic particle and ultrasonic test gear is used for assuring the integrity of the valve bodies,and hydrostatic and nitrogen pressure testing up to 30,000 lb/in^2 is possible.

At the ball valve factory at Sealy similar test equipment is available but in addition Cameron had developed a hydrostatic valve test rig which imposes no end loading on the valve.

The training centre which runs courses for customers and also to train Cameron staff was interesting for the range of sectioned models of the Cameron product range, and for the video studio in which the training staff could produce instructional films.

Descriptive Literature obtained:

Catalogue of Cameron valve products.

NOTES ON A VISIT TO ROCKWELL INTERNATIONAL CORPORATION, RESEARCH LABORATORIES, PITTSBURGH, PA, USA ON 14 MARCH 1983

Address: Rockwell International Corporation
400 North Lexington Avenue
Pittsburgh, Pennsylvania 15208
USA
Telex: 866241

Persons seen: J P Tucker, Product Sales Manager
Flow Control Division. Tel (412) 247-3308
G L Kappes, Manager Export Department
Flow Control Division. Tel (412) 247-3318
W J Ofsanik, Manager, Export Order Group Export Department
Flow Control Division. Tel (412) 247-3315
E A Bake, Research Manager, Valve Engineering & Research
Flow Control Division. Tel (412) 247-3755
H W Fisher, Manager, Gas Products Engineering Research
Municipal & Utility Division. Tel (412) 247-3359
D Yanov, Manager, Water Products Engineering Research
Municipal & Utility Division
C W Hartle, Manager, Materials Engineering
Valve Engineering. Flow Control Division. Tel (412)247-3724
S P Smith, Computer Aided Design Department
Valve Engineering Flow Control Division

Facilities:

Purpose: The extensive research facilities have been set up to develop the corporation's valve product range and its water and gas meter products.

Brief Description:

The facilities are considered under the following main headings:-

1 Valve development and testing
2 Metallurgical, mechanical and chemical laboratories
3 Gas Flow Laboratory
4 Water Meter Test Laboratory

1 Valve development and testing

a Model Shop. A well equipped workshop provides wooden models for air flow test rigs, perspex models and various parts of test rigs as needed, also parts for prototype valves.

b Steam flow loop. An in-house designed rig can supply either steam at 2,700 lb/in^2 at saturation temperature (approximately 670°F) or if required a superheater can be brought into circuit to give a flow of 2000 lb/hour at 1000°F. The steam having passed through the valve on test is vented via a stack to waste. The steam generator is oil or gas fired and a water de-ionisation plant supplies the generator. Tests for seat tightness, stem packing are made and the valve operated repeatedly.

c Water Flow Loop. Flows up to 2000 US gal/min at up to 200 lb/in^2 pressure used for flow C_v, cavitation, and choking tests. Additionally positive displacement pumps are available to give high pressure drops for particular valve tests.

d Air Flow Facility. For model testing of valve profiles (using wood or clay profiles) a centrifugal blower with a variable throttle inlet blows air through an orifice plate, then through a reducer, a test length containing pressure taps and then a diffuser to atmosphere. A bank of single limb air water and air mercury manometers is used for orifice differential measurement and the pressure taps in the test section.

e Valve Cycling Facility

Three similar test rigs had been constructed in which the valve body was held in chain clamps on the pedestal of a drill press and the actuator was clamped to the adjustable swivel table. A differential pressure is created across the closed valve and it is opened up against this pressure. A test consists of, say, 4000 reversals.

A test station some 15 miles away from the main laboratories has been in existence for nearly 30 years and contains the following valve test facilities.

f 24-inch Pipe loop. A loop of piping is supplied from a circulator pump. Variable speed (mechanical variator) 150 HP 17000 US gal/min at 20 feet head.

Flow measurement by Dall Tube. The loop is pressurised to 100 lb/in^2 with compressed air and the test section containing the valve on test (C_v) is provided with a number of pressure tappings leading to single limb Hg manometers.

No throttling provided - flow rates altered by varying speed. It is necessary to run pipe friction tests on the pipe work at least annually because the pipes roughen with weathering. Facility used in summer months only.

g Bend rig. Only a few valve standards give requirements for bend tests so tests have been devised by Rockwell.

A strong bed with yokes holds valve and pipe length up and downstream of the valve. Two hydraulic rams push up pipe either side of valve creating bending movement in pipe and valve. The bending movement is limited to that which would cause permanent deformation across the whole cross section (not extreme fibre) in a normal wall thickness pipe and the valve is opened and closed to ensure correct operation. In practise a thicker walled pipe is used to prevent actual pipe shearing.

h Slurry rig

A slurry centrifugal pump circulates water to which sharp foundry sand is added by belt conveyor to a hopper reservoir with mixer. Downstream of the pump a test section contains the valve on test and the velocity in the section is twice the normal pipe velocity. One month's continuous testing is said to be equal to 5-10 years life under the worst conditions.

j Fire safe Testing. The rig will test valves to API 607 standard. 3 gas burners giving 6 x 10^6 BThU/hour each play on the plug or ball valve under test. The valve is filled with water at 105 lb/in^2 and total leakage during test is measured by drop in level of pressurised water tank. The seat leakage is collected (as steam) in the downstream pipe, condensed and the quantity measured. The test is run for thirty minutes.

k Blow-down test rig. A 330 cuft storage capacity has been constructed from a pipe loop hidden under a hill; to this has been added a further 600 cuft from 12 ca bottles. The capacity is charged from a reciprocating compressor which may take up to 2 days to charge from atmospheric pressure. The maximum pressure of the rig is 1500 psi. Air is merely allowed to escape through the valve on test (through a muffler to deaden the sound) by using a quick acting valve or a bursting disc to release the flow. Additionally to test atomic plant valves, a frame is connected to the pipe and valve head. 4 hydraulic rams can impose stress on the pipe in any combination, compressive or extensive and the fifth ram pushes against the head of the valve to impose a bending stress upon it. During blow down the valve is actuated to prove that under seismic stress conditions the valve can still operate.

l Check valve test rig. A water filled pressure vessel with compressed air above the interface leads to the downstream side of the check valve on test which is kept open by a fine wire. The pipe continues beyond the valve to a bursting disc. At disc rupture the water is forced through the check valve by the compressed air and slams the check valve shut. A high surge pressure would normally be registered but the facility has been used to test a controlled closure check valve which closes more slowly (one sec) and limits the pressure surge to acceptable limits.

2 Metallurgical, Mechanical and Chemical Laboratories

a Metalographical Laboratory. A well equipped laboratory with facilities for checking the metalographic structure. A Bausch and Lomb microscope with magnification of around 5000X. A digital type micro hardness tester of Tukon make used for measurement of hardness of very thin coatings of nickel silver etc.

b Chemistry Laboratory. Means for doing rubber and plastic test, coating test. Infrared spectrophotometer (for non metallic) for material analysis. Atomic absorbtion spectrometer for analysis. Weather-O-Meter is used for creating all types of climatic conditions for testing the behaviour of materials under actual conditions. Salt spray being used for testing under saline conditions.

c Sealant or Lubricant Laboratory. Accelerated field test on lubricants, actual field test and comparison on both. Test on friction to find out the friction characteristics of lubricant.

d Physical testing. A computer aided testing machine is used for creating load cycles, strain cycles etc so that sample material can be tested and the test datas recorded as well. If need be a heating element can be incorporated to heat the test piece to get test values at higher temperature.

A Charpy V-notch tester is used for estimating impact values of materials. A cooling equipment is used so that materials can be tested at sub-zero conditions.

A scanning electron microscope with a maximum magnification of 200,000X is used for studying the various metal spray and weld used for hard facing of valves.

A friction testing machine is used for estimating dry friction constants of any two materials.

3 Gas Flow Laboratory

The main work of the laboratory was to improve methods of calibration of their domestic gas meters. Normally 50 or 60 bell provers were used in their plant for this work but a super bell prover had been developed using a microprocessor as a control device. A pressure temperature probe accurate to 1 part in 10,000 was inserted at the start of the test into the gas meter inlet connection.

The bell prover is calibrated by using a piston prover in which the piston proper does not touch the cylinder wall. Two wipers with glycerine between are used as the seal and the piston is driven by a lead screw with a linear digitiser to measure stroke (1 part in 40,000 counts). The volume of the piston prover is determined by high frequency radio. An antena is mounted in the bottom face of the cylinder and a variable wavelength emission is produced until resonation is achieved. The amplitude of resonance at the measured frequency enables the distance between under side of piston and cylinder end to be measured and also the diameter of the cylinder. Volume determinations accurate to 4 parts in 10^5 are claimed.

A pressurised air loop using a circulator fan is available for calibrating gas turbine meters. The loop flow standard is a gas turbine master meter calibrated against a 500 cuft bell prover.

4 Water Flow Meter Laboratory

Fairly conventional water meter test stands were used for calibrating domestic Rockwell semi-rotary piston type water meters.

A larger rig using dynamic weighing techniques (no diverter) and a number of fixed speed centrifugal pumps was evident.

Descriptive Literature obtained:

1 Rockwell News (Volume 10, No. 1, Feb. 1983).

2 Valves and Actuators from Flow Control Division No V-5500.

3 Rockwell International Flow Control Division.

Published papers obtained:

1 Nuclear containment of postulated feedwater linebreak by E B Pool and Herbert Brinkman. Published in A Flow Line magazine technical article by the Flow Control Division, Rockwell International.

2 Pressure drop of straight-through flow valves by Earl A Bake.

3 Design of gas pipeline blowdowns by R J Gradle.

4 Quick-closing equiwedge isolation valves. Ongoing qualification by E A Bake and J B Gallagher. Published in A Flow Line magazine technical article by Flow Control Division Rockwell International.

5 A model for check valve/feed water system water hammer analysis by M J Kirik and R J Gradle. Article was presented at the American Society of Mechanical Engineers, San Francisco, August 12-15, 1980.

6 High pressure gas flow test facilities and their intercomparison (a research report) by Winston F Z Lee.

7 Testing and calibrating procedures for turbine meters by Joseph L Pond published in Pipeline & Gas Journal, July/September 1981.

8 Flow calculation handbook for piping systems. Fourth Edition. February 2, 1983 Rockwell International

NOTES ON A VISIT TO DANIEL INDUSTRIES INC, FLUID DYNAMICS RESEARCH LABORATORY, HOUSTON, TEXAS, USA ON 9 MARCH 1983

Address: Daniel Industries Inc
Corporate Research & Development
9720 Katy Road
PO Box 19097
Houston, Texas 77224
Tel: (713) 827-5038
Telex: 77-5421

Persons seen: Dr R G Teyssandier, Director, Fluid Dynamics Research

Facilities:

Purpose: Originally created to calibrate the company's range of flow metering products, particularly turbine meters, the facilities have now been handed over for research purposes and new turbine meter calibration facilities have been created.

Brief description: Water and air research facilities are available.

a Water facilities

An enclosed reservoir containing natural untreated mains water supplies the water for both the prover and the weigh tank calibration systems. In the former system 30 in, 8 in, and 4 in ball provers are available and in the latter 100 and 4000 lb weightanks are used. The provers are all in closed loop systems the five service pumps merely bridging an inlet and outlet manifold. The weigh tanks have a conventional diverter system but dynamic weighing is used for most work although static weighing can also be used to check the dynamic systems. No head tanks are employed. Mercury/water and water/air manometers are used for differential pressure measurement, but this is being superseded by pressure transducers and a data acquisition system.

b Air facilities

A closed loop pressurised to 50 psi is used in conjunction with master air turbine meters calibrated regularly at NBS Boulder Laboratories as the basis of calibration of the company's range of gas turbine meters.

Both facilities are more fully described in the brochure accompanying these notes.

Descriptive Literature obtained:

1 Daniel Industries Inc Flow Products Division Liquid/Gas Calibration Laboratory and Meter Prover Facility.

2 Daniel Industries Inc Products Catalogue

a Flow Products Division
b Electronic Products Division

NOTES ON A VISIT TO HONEYWELL INC, FORT WASHINGTON
USA ON 15 MARCH 1983

Address: Honeywell Inc
1100 Virginia Drive
Fort Washington
Pennsylvania 19034

Persons Seen: C W Johnson, Manager International Sales Process Control Division. Tel (215) 641-3084
J T Emery, Product Manager- Valves, Process Control Division Tel (215) 641-3788
R I Morrison PE, Manager Customer Quality, Process Control Division. Tel (215) 641-3407
M Singley, TDC 2000 Development
C Murtaugh, Manager, Flow Laboratory
J Tarquino, Manager, Diffused Silicon Pressure Transducers

Facilities:

Purpose: The laboratory and valve test facilities have been provided to develop the valve and flowmeter product range of the organisation.

Brief description: Whilst the Fort Washington factory produce a wide range of products, including the TDC200 microprocessor process controller and employ 2300 employees at the plant, the description is restricted to the test and research facilities relevant to our present enquiry.

a Water Flow Laboratory

A basement reservoir contains 26,000 gal water. Through the end wall of the reservoir, pipes lead to 4 pumps of 250, 150, 75 and 25 HP respectively. The pump outlets lead to 4 test lines of 12, 6, 4 and 2-inch diameter. Maximum flowrate - 6,500 US gal/min at a pressure of 90 lb/in^2.

Immediately upstream of each test section a reference electromagnetic flowmeter is used as the reference standard. Two control valves upstream and downstream of the test section are used to control the flow rate through the test section, with a further control valve situated in a bye-pass returning to the reservoir giving a measure of pressure control over the system. Diverter and weightank systems are provided (tank capacities 5,700 and 47,500 lb) but are only used to calibrate the reference electromagnetic flowmeters. Each test line is provided with its own control panel on which valve positions can be set and the reference flowmeter indications read etc.

For measuring stem loads and valve torque, axial and torque load cells are used; these are mounted in adaptors of Honeywell design so that they can easily be applied to valves on test and the valve open or closed to the required setting as desired.

The rigs are used for C_v tests but the determination of a valve's actuator requirements and the investigation of instabilities over the flowrate range of the valve are held to be more important. It is normal to record the results of such tests through signal conditioning amplifiers on to a tape recorder for subsequent analysis.

Evaluation Laboratory

Valves and associated equipment is tested at the prototype stage in this laboratory. Equipment includes walk-in temperature chambers, shaker tables (400 lb load 4g accelerations), drop testing table.

Production Valve Testing Equipment

The normal range of hydrostatic leak testing equipment is used for seat and body valve tests. The seat leakage is measured by variable area flowmeters (Fischer & Porter).

Descriptive Literature Obtained: None

NOTES ON A VISIT TO YARWAY CORPORATION, PHILADELPHIA, USA
ON 16 MARCH 1983

Address: Yarway Corporation
Blue Bell, Pennsylvania 19422, USA
Telex: 84-6450
Tel: (215) 825-2100

Persons seen: C R Bardes, Manager, Export Marketing
R H Seelaus, Manager, Admin and Communications
R J Mattie, Vice President and General Manager International Operations
H K Hetz, Vice President, Product Planning & Development
D Kalix, Manager, Test Laboratories

Facilities:

Purpose: The valve research and test facilities were developed to test steam traps and valves, and in particular the corporation's range of pressure breakdown valves, and bye-pass valves.

Brief description: The steam trap test facilities were not of direct interest but the steam generators and accumulators used in the rigs were of interest because of their possible application at Palghat for valve packing tests, and relief valve setting tests. Accordingly the following details were noted: Boiler 1 40 HP 2000 lb/in^2 saturated steam
Boiler 2 100 HP 600 lb/in^2 saturated steam

Supplier: Vapor Corporation, Chicago

Model No.: Va-Power KR7-D4626-R3NK

Approximate price: each $30,000

Fuel: gas fired. Type: once through with baffled tank for collecting moisture.

Detailed circuit drawing enclosed.

Cold water test loop. The enclosed diagram of the facilities shows that 3 pumps take water from a reservoir through a pressure control valve. A 4-inch diameter bye-pass line with a control valve and vortex type flowmeter included allows a measure of pressure and flow control at the valve on test. Downstream of the test section the line splits and contains a vortex flowmeter in each line. Isolating valves determine whether one or the other or both flowmeters are to be used. Back pressure control valves are also installed. The lines reunite downstream and return to the sump. Cavitation was obviously present downstream of the back pressure control valves when the UNDP study team were present. It was somewhat unusual to see that plastic pipes had been used throughout the test rig.

A high head pump teed off the main supply line and with its own 2-inch diameter test section gives a higher pressure supply for smaller valve tests. Pump details 125 US gal/min, 600 lb/in^2, 10,000 RPM, 100 HP.

A control panel containing pressure transducers, vortex flow meter readouts, pump controls, valve positioners was in use and the majority of readings could be taken out as electrical signals on to an 18 channel chart recorder. The vortex meters had not been calibrated but their flow rate ranges overlapped and when arranged in series it was claimed that their indications agreed.

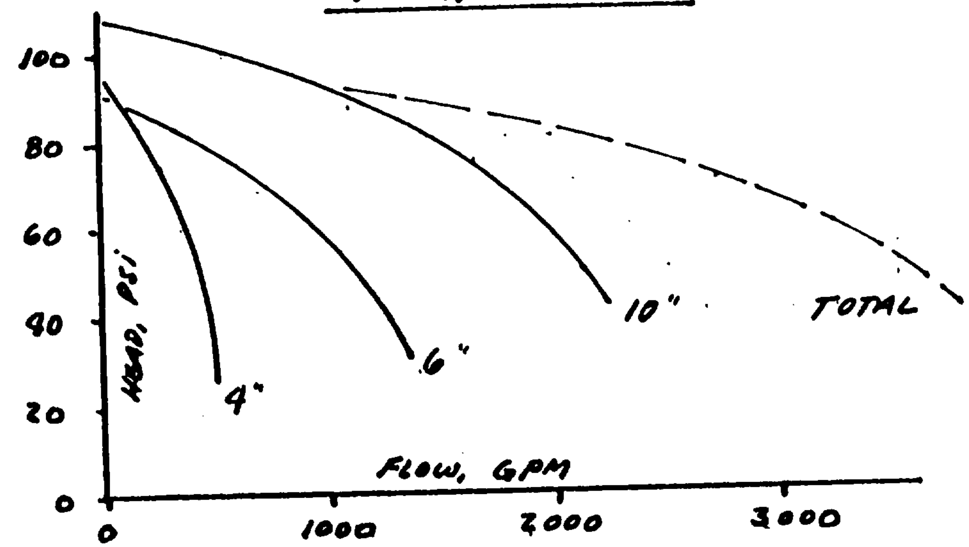
Tests on a Yarway bye-pass type valve were seen in progress and the bye-pass flow was measured by variable area type meters connected by snap on type connectors to the valve bye-pass.

Descriptive Literature Obtained:

Equipment for Steam Power Plants and Chemical Processrs. PPP5M 1282B Yarway Corporation.

TECHNICAL DATA

PUMP CURVES



PUMP DATA

TYPE : CRANE DEMING, VERT TURBINE

SIZE:	4"	6"	10"
RAT'G.:	20 HP	50HP	100 HP
OUTPUT:	400GPM	900GPM	1800 GPM

FLOWMETER DATA

TYPE: EASTEC, VORTEX SHEDDING

SIZE:	4"	8"	4"
MAX FLOW:	1000GPM	4000GPM	1000 GPM

OUTPUTS

FLOW: DIGITAL, PNEUMATIC ANALOG

PRESSURE: PNEUMATIC ANALOG

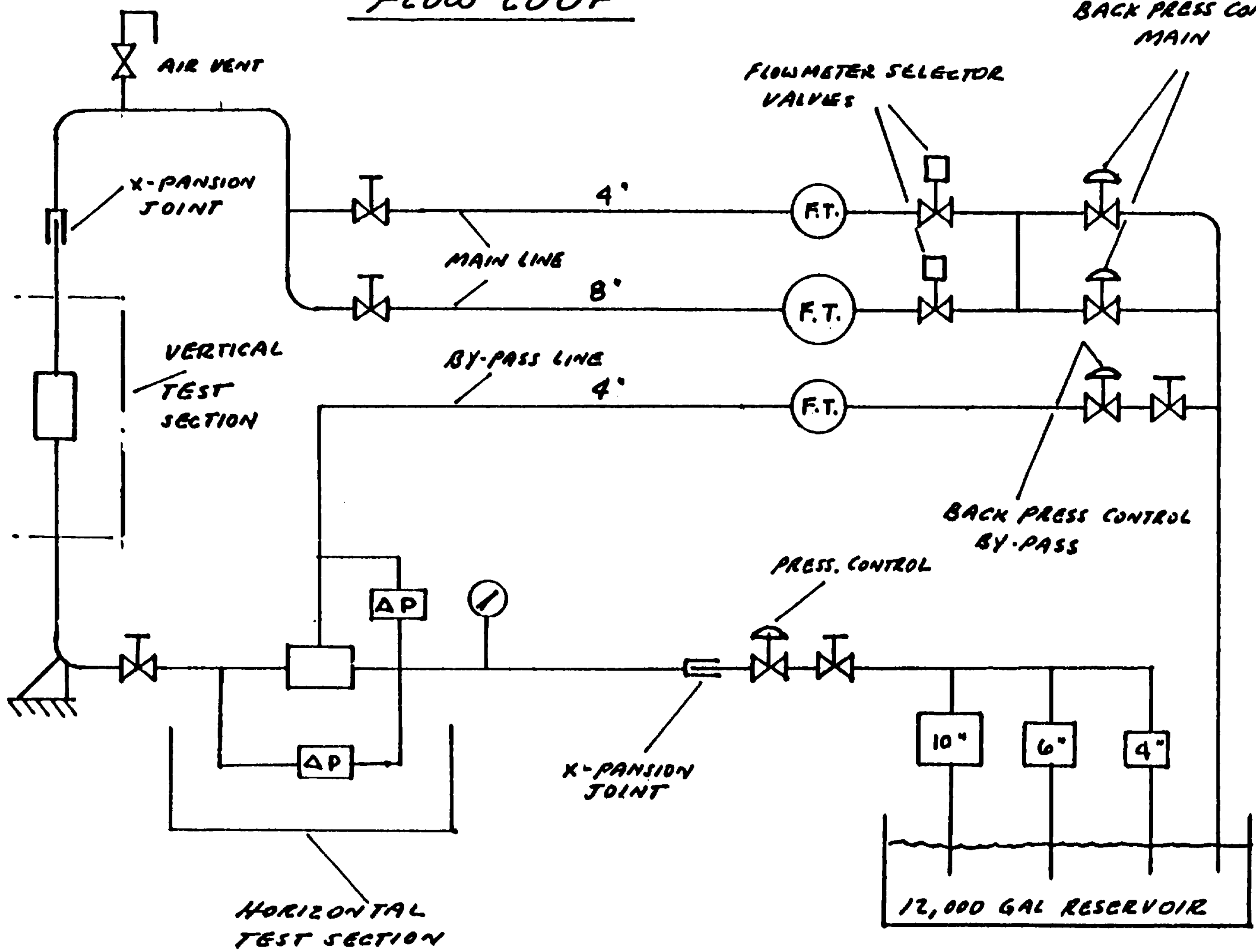
DIFF. PRESS: PNEUMATIC ANALOG

TEMP : PNEUMATIC ANALOG

LEVEL: PNEUMATIC ANALOG

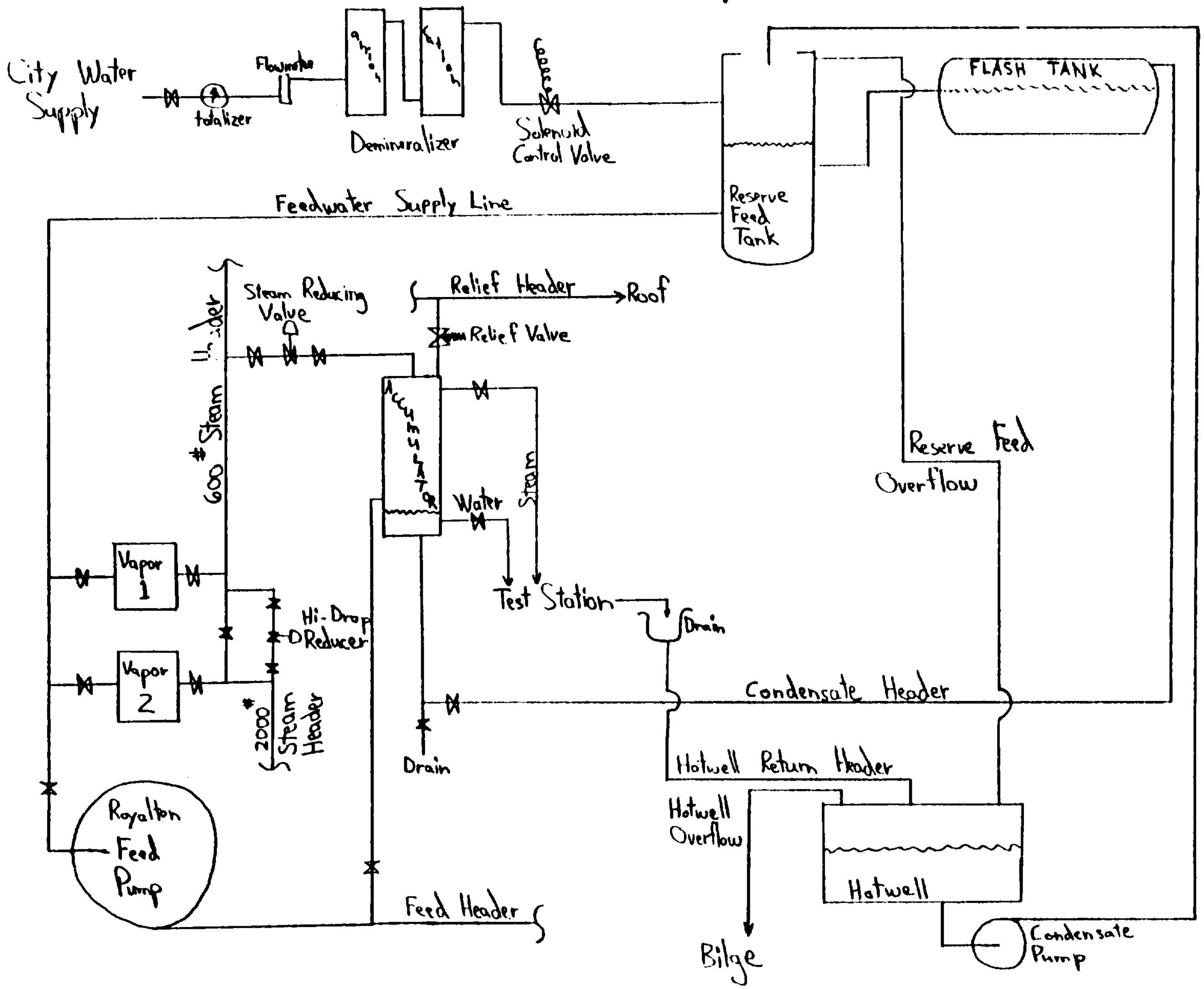
H.R. THIENG
21 AUG 79

FLOW LOOP



H.R. THIEME
20 AUG '79

YARWAY Steam Plant Simplified Schematic

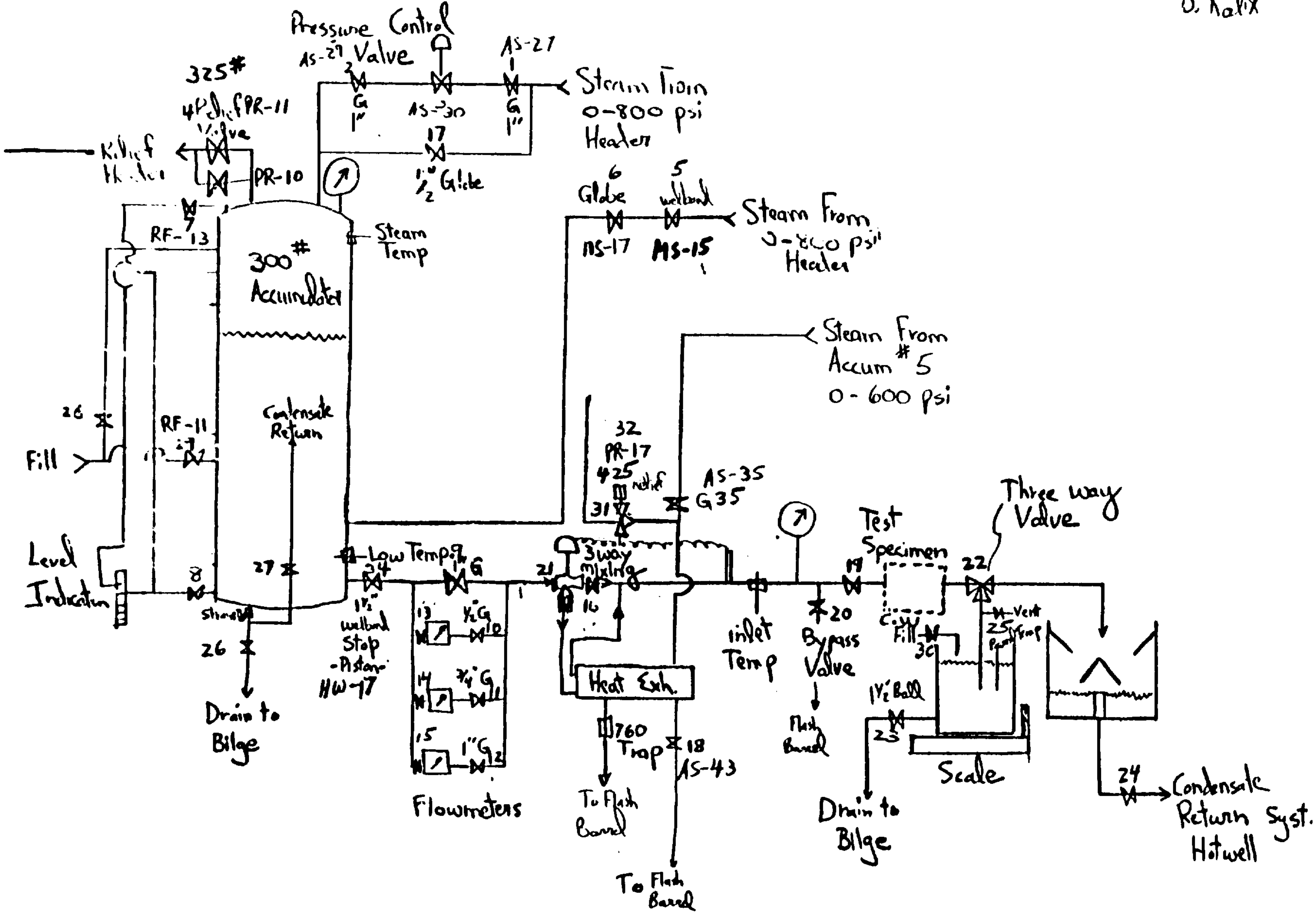


27 Dec 79
D. Kalix

- 43 -

Proposed Hot Water Capacity Test Station

17 Oct
D. Kalix



- 44 -

7.1 Figures and Diagrams

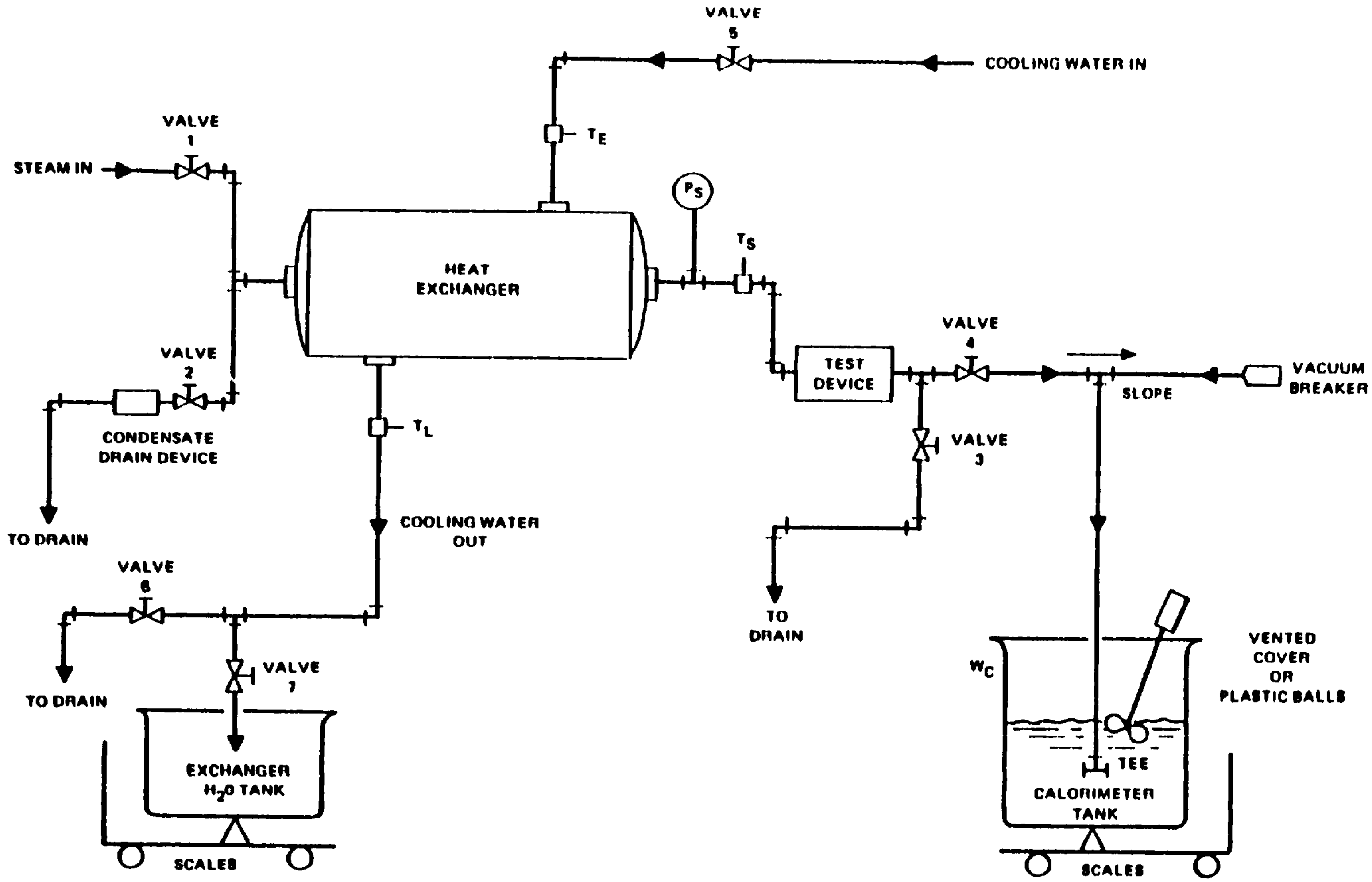


FIG. 7.1.1 TEST ARRANGEMENT FOR STEAM LOSS TESTS

NOTES ON A VISIT TO MASONEILAN DIVISION,BOSTON, MASS, USA
ON 17 MARCH 1983

Address: Masoneilan Division
McGraw-Edison Company
Norwood MA 02062 USA
Telex: 924410
Tel (617) 762 4600

Persons seen: H W Boger, Vice President Engineering
R J Clark, Senior Development Engineer
Laboratory Supervisor

Facilities:

Purpose: The research laboratory, originally constructed some 15 years ago, is used for the research and development of control, butterfly, plug and special valves manufactured in 3 factories of the organisation in the surrounding region.

Brief description: A valuable visit in which it was a pleasure to talk to an expert in the field of hydrodynamic testing of valves and who had made significant contributions to the drafting of the Instrument Society of America standard "Control Valve Capacity Test Procedure": ISA S75.02 1981.

Water Test Facilities

An underground covered reservoir feeds through a bay wall to 3 fixed speed centrifugal pumps of 75, 75 and 50 HP respectively. The two 75 HP pumps are arranged to run normally and at start up in parallel but can be valved to run in series. Each pump delivers to its own test line (2, 6, 12-inch diameter) and the 3 lines are united before a section containing two electromagnetic flowmeters of 3 and 8-inch diameter, the smaller in a loop, valved either to run in series with the other, or to be isolated and not used. The ranges of the magnetic flowmeters overlap and one can be checked against the other at a common flow. A flow regulating valve at the end of the circuit controls the flow rate. It will be noted that only one test line can be run at a time. The magnetic flowmeters are calibrated periodically by using a calibrated volumetric tank into which the flow is diverted for a measured time.

Blowdown rig. Three similar compressors operating in parallel feed into 2 pressure vessels. An 8-inch diameter pipe fitted with a fast acting Camflex valve leads to the valve on test via reducers if necessary. Downstream of the valve on test the air is led away into a brick/masonry chimney. The emergent air velocity to atmosphere is less than 100 ft/s at maximum flow. The compressed air is dried by pellet type none heated driers made by Zurn Industries of Erie PA, USA.

Noise Measurement Facilities

A semi-anechoic chamber can be built around any pipeline containing a valve on test. Inside is situated a microphone for testing according to the IEC standard or the DIN standard. A pad and accelerometer welded to the pipe is also used. It is possible to detect incipient cavitation acoustically before a change appears as a shift in pressure drop. A data acquisition system is used consisting of compatible units of scanner, programmable voltmeter, real time analyser, mini-computer, floppy disc store, a Bruel & Kaer digital frequency analyser and a fourier frequency analyser. When using the blow-down rig because of the rapidly changing conditions the digital frequency analyser is used.

Torque and Force Measurement

Torque is measured by using a pneumatic positioner, measuring the piston area and linkage arms, and measuring the air pressure. Instabilities are not measured or studied. Load cells are used for force measurement.

Literature Obtained

No descriptive brochures were obtained, but we were given a copy of ISA.S75.02 1981 "Control Valve Capacity Test Procedure".

Training and Fellowship Possibilities:

It would appear that there are possibilities, but this depends to some extent on what training is required and whether such work is being conducted at the time.

NOTES ON A VISIT TO KENT INDUSTRIAL MEASUREMENTS, STONEHOUSE, UNITED KINGDOM ON 21, 22 MARCH 1983

Address: Kent Industrial Measurements Ltd
Flow Products
Oldends Lane
Stonehouse, Glos GL10 3TA
United Kingdom
Telex: 43127 KENTFPG
Tel: (045382) 6661

Persons seen: Mr W H Cooke, Director Sales
Mr R S Medlock, Consultant
Mr G Brown, Head Flow Measurement Laboratories

Facilities:

Purpose: The air and water flow research facilities were installed to aid in the development of the flow measurement products of the company and to provide facilities for their routine calibration.

Brief description:

Water test facilities: The large flow loop is being developed in two stages and is currently at the end of the first stage. Thus the reference flow standard for the rig is a series of orifice plates calibrated by the National Engineering Laboratory. In a subsequent development phase a large meter prover will be installed and the reference standard for day-to-day use will be a series of turbine meters which will be calibrated by the meter prover. A large underground reservoir forms a common sump for all the water test rigs, but for the large flow loop three fixed speed centrifugal pumps (1.2 m^3/s - 2 off and 0.6 m^3/s - 1 off) and a variable speed centrifugal pump (0.6 m^3/s) provide a maximum flowrate of 2.8 m^3/s at an operating head of 2.7 bar. The large flow loop is well described in the accompanying brochure, but the smaller facilities are merely mentioned in passing.

In these rigs dynamic weighing techniques using lifting steelyard type weighing machines are used. In one rig, a horizontal sleeve type control valve used in conjunction with a horizontal type diverter similar to that developed at NEL is being installed but is not yet operational. A useful discussion on the problems of maintaining acceptable levels of water purity in the sump showed that with untreated local water some calcium deposition on cast iron pipework is evident, that the sump is drained at six monthly intervals (2-3 days to drain, 2 days to clean sump, 2 days to re-fill). The sump has a water resistant concrete finish of the type used to line drinking water reservoirs and to a British Standard Specification. Mr Brown warned of the importance of avoiding algal infestation of the water saying that once present, complete elimination is almost impossible. He was against the use of biocides in the water since they invariably cause foaming. Whilst chlorination or the use of copper sulphate was a possibility, he strongly recommended getting expert local advice on the problems of water treatment for the Palghat Research Centre.

Air test facilities. These are used for development work and also for the calibration of steam meters. A simple circuit consisting of fan, damper, borda or conical inlet leads to a test section. Normally orifice plates (precalibrated in water) are used to measure the flow rate.

A further discussion with Mr Medlock on the morning of 22 March on the facilities at Palghat resulted in him advising the provision of a large sump to allow for future expansion, a constant head tank and basic gravimetric flow measurement facilities and that a prover loop should be allowed for in the basic design for inclusion at a later date. Since Kent are about to provide a water prover loop for their own facilities they would be well placed to offer a similar design for the Palghat centre.

Literature obtained:

World of flow 2. "Leading the field in Flow Calibration". Brochure describing the Stonehouse test facilities.

Training and Fellowship Possibilities:

No training of external students has been done in the recent past, but no problems are anticipated in undertaking such a scheme in the future.

NOTES ON A VISIT TO ROTORK CONTROLS LTD, BATH, UNITED KINGDOM ON 22 MARCH 1983

Address: Rotork Controls Ltd
Bath, United Kingdom
BA1 3JQ
Telex: 44823
Tel: (0225) 28451

Persons seen: Mr A N Forsyth, International Sales Liaison
Mr T W Eassie, Rotork Controls Chief Executive

Facilities:

Purpose: The company produces valve actuators and have designed and manufactured a range of sophisticated test and calibration gear for the production testing of their products.

Brief description: This was a short visit, hastily arranged, whilst the team was in the Bath area, as a substitute for the visit to the Yarsley Laboratories scheduled for this day.

In essence, the test requirements for valve actuators are those of checking that the torque or thrust specifications of the actuator are met, that the overload performance of the actuator does not result in excessive heat or damage and that the operating load and travel limit switches are set correctly. Rotork have developed test rings in which dynamometers measure the torque and thrust capabilities of the actuator, and in the same rig the overload characteristics are measured and the various limit trip switches set. Endurance testing is also undertaken, and for pattern approval tests of prototypes climatic chambers are also available.

The visit was useful in that it raised the question of how far such facilities should be provided in the Research Centre at Palghat. Further discussions with Indian valve manufacturers and others will be necessary to ascertain their views. The study team's opinions are divided.

Literature obtained: None

NOTES ON A VISIT TO NATIONAL ENGINEERING LABORATORY, EAST KILBRIDE, UNITED KINGCOM ON 23, 24 MARCH 1983

Address: Department of Industry
National Engineering Laboratory
East Kilbride, Glasgow G75 OQU
United Kingdom
Telex: 777888
Tel: (03552) 20222

Persons seen: Dr D A Bell, Director
Mr H L Wunsch, Marketing Controller
Dr E A Spencer, Marketing Division
Mr N W King, Hydrocarbon Flow Measurement Business Centre
Mr J Peters, Fluids Business Centres, Pump Research
Mr R W W Scott, Fluids Business Centres
Mr J Currie, Fluid Power Business Centre
Mr D Smith, Fluids Business Centres, Water Flow Measurement
Dr W C Pursley, Fluids Business Centres, Hydrocarbon Flow Measurement
Mr J Reid, Fluids Business Centres, Air and Gas Flow Measurement
Mr A N Bolton, Fluids Division, Noise and Cavitation Studies

Facilities:

Purpose: The National Engineering Laboratory is the United Kingdom centre for mechanical engineering research and its many functions and facilities are explained in the accompanying booklet "Introducting NEL".

The visit was made to see the valve and flow measurement research and test facilities and to consult with the UK experts in these and associated relevant fields. The programme of the visit pre-arranged by the UNIDO adviser is given as annexure 1 to these notes.

Brief description: The flow measurement research facilities for water, air and gas are described in detail in NEL Report No 665 enclosed with these notes. However the fact that these facilities and their staff are all housed within one building together with the ancillary scientific disciplines of cavitation, noise and vibration applied to fluid flow ensures a cross-fertilisation and interplay of ideas which is probably unique in this field.

Dr Bell in an introduction to the work of the laboratory explained the organisation of the British Civil Service and the relationship of government laboratories to the departments and the Ministries they serve. He showed how the organisation of the laboratories and the programme of work undertaken, changes and adapts to changing government policies and industrial requirements. The present matrix organisational structure adopted for the laboratory was described and the difficulties encountered in its evolution were discussed. The financial organisation and the contributions required from industrial work was elaborated together with methods adopted to try to ensure the adoption by industry of the research findings at NEL.

Dr Spencer in talking about the organisational planning of a flow measurement research centre felt that the most difficult problems always occur at middle management levels. The difficulty was to recruit and retain staff who have a sufficient knowledge of the subject and the necessary motivation to be able to solve practical problems. In his experience pure academics were unsuitable for the work but on the other hand technical and practical competence to a higher order than that say of a production engineer was required. He felt that what was needed was a group of people having a sound mechanical engineering training not necessarily with a degree but at least with good Polytechnic qualifications. To lead this group a lesser number of people with a good degree having done worthwhile research in industry, and having MIMechE qualifications or equivalent or post graduate experience. Specialists would also be required, for example a Mechanical and Electronic Specialist and certainly a Mechanical Engineer versed in Computer Programming, statistics, mathematical modelling etc. Dr Spencer listed as his priorities in setting up a Research Centre:

a Find 2 people who are going to be the driving force.
b Find 4 or more lieutenants to complement them.
c Find the necessary individual specialists having specific skills
d Recruit suitable assistants
e Establish a very sound administrative organisation
f Ensure the existence of a first class workshop.

As far as research facilities were concerned he recommended initial concentration on a good general water test facility with one or two smaller separate facilities in which conditions and fluids could be changed. However it was vital to build up the measurement performance side too and the laboratory should immediately seek to build up a competence in the measurement of pressure, temperature, flow (both overall and local point measurement). He welcomed the idea of staff being sent for training at NEL and felt that a period of less than four months is too short but that the "learning curve" begins to flatten out after about six months. He felt that one or two of the Palghat staff should take up a research project at some other research centre whilst waiting for Palghat to be completed. When questioned about the possibility of a "twinning" link between NEL and Palghat and after consultation with the upper management level of NEL he confirmed that UNIDO could be informed of NEL's agreement to it in principle. The UNIDO adviser agreed to let Dr Spencer have an outline proposed programme for his comments.

Mr Currie's team's work in noise measurement and control in oil hydraulic systems was examined and the rigs built to evaluate hydraulic silencers and a "quiet" valve were studied. The techniques of modal analysis and finite element stress methods were demonstrated on a computer with VDU and a computer aided design programme with tablet was also shown to the visitors.

A particularly useful examination of the state of the art in research into cavitation, erosion and cavitation noise and vibration was provided by Mr King. Besides describing his own work and test facilities he reviewed the parallel approaches of other workers in the field. On the one hand the metallurgical approach ie to find materials which had good cavitation erosion properties, contrasted with the design approach to determine what hydraulic parameter causes the sudden rise in cavitation erosion at a given cavitation number. He introduced the concept that all damage to a piece of hydraulic machinery eg a valve is the result of 3 things - abrasion, corrosion and cavitation erosion. If these were plotted as 3 dimensional rectangular coordinates then it becomes clear that their combined effect can be much worse than the sum of two effects alone. For example the sum of corrosion plus cavitation erosion is much worse than the separate sum of both. Additionally particles in the water can remove the natural corrosion masking layer. Asked about the qualifications necessary to do worthwhile work in this field he felt that a person would need to be experienced in the problems of flow measurement, be knowledgeable in the physics of noise propagation, have worked in research with a pump or valve firm, be about 35 years old and have an open mind about approaches to the problems.

As far as training someone at NEL was concerned he could certainly use someone on a six month's fellowship and ensure as far as possible that he was deeply involved in the practical problems of his section's work. If required, NEL would be pleased to provide the design of a recirculatory or other type cavitation rig on which useful valve material and profile research could be undertaken.

Mr D Smith described the design concepts and demonstrated the equipment of the water test facilities in the laboratory. He went on to enumerate the types of test and the problems that Industry submits to NEL in his particular field showing that once facilities and expertise is known to exist, then work begins to flow in from meter manufacturers and to a lager extent from meter users who tend to exhibit doubts about the meter performance data, and doubts about its applicability. In some cases this results in research in the laboratory and in some cases site testing and field research. Currently he was involved in problems concerned with flowmeters, filters, valve and pipe roughness and hose corrugations.

Mr Reid demonstrated the work of the gas flow measuring section. The high pressure gravimetric gas flow facility and its applicability to the testing of safety valves as well as the accurate calibration of flowmeters was shown. The ambient conditions rigs housed in an air conditioned side laboratory was of particular interest as was the use of air in the modelling of large scale duct and vessel flows.

Mr Bolton and his staff had prepared an intensive demonstration of noise measurement techniques in liquids and gases at low, middle and high frequencies. Also shown was a data logging system used in investigating pump surging under rapidly changing conditions. A computer programme using the "method of characteristics" for modelling fluid transients in complex systems was also shown. The study team recognised the relevance of all these techniques to the future work of the Palghat centre and were most grateful to receive from Mr Bolton carefully prepared notes on the equipment used and the order of costs of it.

At the end of the two days of meetings at NEL a review of the visit was made with Mr Wunsch. In essence he confirmed

(a) that a fellowship arranged at NEL should be for not less than six months, and in his opinion a year would be better. That with the present cost of living a student could not exist on less than £3,000/annum whilst working at NEL.

(b) that advice on particular aspects of laboratory design could be purchased from NEL in the fields of cavitation, noise, instrumentation expertise etc.

The extent of this NEL involvement would depend on how far the UNIDO adviser was himself involved in the Palghat project but in any case, and as a budget figure NEL costs were of the order of £250 per day plus any travel or subsistence expenses.

(c) that a twinning link between NEL and the Palghat centre would be welcomed by NEL.

Literature obtained:

1 ISO 3741-1975(E). Acoustics - Determination of sound power levels of noise sources. Precision methods for broad-band sources in reverberation rooms. 0.1 Related International Standards.

2 Margetts, E. J. "Fan noise measurement and analysis". National Engineering Laboratory. Industrial Noise and Vibration Problems. 27-29 Jan 1976, Paper No 12.

3 Bolton, A. N. "Predicting Fan Sound Pressure Levels". National Engineering Laboratory. Industrial Noise and Vibration Problems. 27-29 Jan 1976, Paper No. 13.

4 McNulty, P. J. "Measurement Techniques and Analysis of Fluid-Borne Noise in Pumps". Department of Industry, May 1981. NEL Report No 674.

5 "Fluid-Borne Noise in Hydraulic Machinery". Brief notes.

6 McNulty, P. J. FIOA "Measuring Cavitation Noise".

7 Pearsall, I. S. and McNulty, P. J. "Cavitation Inception in Pumps". Journal of Fluids Engineering, March 1982, Vol 104, pp99-104.

8 McNulty, P. J. "Passive transducer applications for hydraulic measurement". Process Engineering. Nov 1971.

OUTLINE PROGRAMME FOR VISIT OF UN STUDY TEAM (PALGHAT PROJECT) TO NEL
23 AND 24 MARCH 1983

UN TEAM

Wing Commander A K Dhingra, National Project Director
Mr R G Kini
Mr V K Ramakrishnan
Mr P Harrison, Team adviser

WEDNESDAY 23 MARCH

0915	Welcome by Dr D A Bell, Director Mr H L Wunsch and Dr E A Spencer, Marketing Division. Introduction to NEL, its relationship with British Industry, its organisation and management; the formulation of research programmes and their modification to suit changing industrial needs.
1015	Reynolds Building (Conference Room) Dr T J S Brain. Introduction to visit to Fluids Business Centres (Flow Measurement and Turbomachinery).
1045	Reynolds Building. Mr J Peters. High-pressure breakdown valves, design testing; aspects of noise and vibration in turbomachines; control characteristics etc.
1220	Dr Spencer's office
12.30-1340	Lunch in Staff Restaurant
1345-1600	Bramah Building. Mr J Currie. Vibration measurement and vibration testing, modal analysis of valves; noise and silencing (liquids and gases); quiet valve designs; torque calibration and measurement.
1600	Dr Spencer's office

THURSDAY 24 MARCH

0845	Reynolds Building. Mr N W King. Cavitation and valves, prediction of inception; cavitation avoidance ; noise and damage. Material research and validity of techniques of sample testing. Collaborative research and need for practical approach. Discussion of Fellowship.
1030	Reynolds Building. Mr D J M Smith. Water flow measurement facilities. Valve test facilities; torque and thrust measurement. Valve pressure loss chartacteristics; control characteristics. Discussion of Fellowships and design consultancy.
1200-1230	Reynolds Building. Dr W C Pursley. Fiscal oil flow metering. Calibration of oil flowmeters. Meter prover research programme.
1230-1340	Lunch in staff restaurant
1345	Reynolds Building. Mr J Reid. Gas flow measurement facilities. Flow modelling and flow in ductwork. Calibration of meters in air. Air and Gas Flow Standards. Pressure relief valves. Calibration of leakage rate meters. Discussion of Fellowship.
1500-1600	Reynolds Building. Mr A N Bolton. Noise measurement in liquids and gases. Safety valves. Reflux valves. System analysis, unsteady flow problems. Computer simulation. Frequency analysers, filters, etc. Discussion of Fellowship opportunities.
1605-1700	Mr H L Wunsch

CIRCULATION

Wing Commander Dhingra (for study team)
Mr P Harrison (for information)

Director
Mr H L Wunsch
Dr E A Spencer
Dr T J S Brain
Dr D T Jamieson
Mr D J M Smith
Mr G Scobie
Dr W C Pursley
Mr J Currie
Mr J Peters
Mr N W King
Mr A N Bolton
Mr J Reid
File NEL/112/11

NEL tour liaison: Mr R W W Scott, Reynolds Building

NOTES ON A VISIT TO EUR-CONTROL KALLE AB, SAFFLE, SWEDEN
ON 28 MARCH 1983

Address: EUR-CONTROL KALLE AB
Box 96
S-66100 Säffle
Sweden
Telex 5312 KAELSLES
Tel (0533) 12640

Persons seen: Mr B E Johnson, Managing Director
Mr H Bosshart, Vice President

FACILITIES

Purpose: The company produces valves and instrumentation for the pulp and paper industry and the test facilities have been designed to allow development of the products whilst running in various grades and types of wood pulp.

Brief description: The facilities consist of circuits of stainless steel pipes and vats with stirrers from which the pulps are pumped through the device being tested.

An interesting cross correlation flowmeter using an optical transducer to recognise pulp density or light reflectance patterns had been developed there.

Also under test were examples of a turbidity meter, and consistency meter (rotary drag plate type). Flow within the rigs was measured by an electromagnetic flowmeter but no means appeared to be available for its absolute calibration.

NOTES ON VISIT TO NV NEDERLANDSE GASUNIE, GRONINGEN, NETHERLANDS ON 29 MARCH 1983

Address: NV Nederlandse Gasunie
Beproevingslaboratorium
Energieweg 17
9743 AN Groningen, Netherlands

Tel: 050 212522

Persons seen: Ir H Bellinga, Engineer in Charge

Facilities:

Purpose: The company operates a national and international gas distribution network, buying gas from both inland and North Sea wells and selling the gas to district distributors in The Netherlands and to Germany, Belgium and France in bulk.

The calibration facilities developed at Groningen and at two other sites in The Netherlands are viewed as essential by the legal metrological authorities to ensure that just measure is sold, and by the company as a means of strict budgetary control.

Brief description: In the distribution network both gas turbinemeters and orifice plates are used in the measurement of flow. Facilities are provided to calibrate these meters in gas at the pressures actually used ie between 1 and 70 bar, against reference meters calibrated or approved by the weights and measures authorities. Gas is tapped from a supply main, its pressure modified to suit requirements by a regulator and passed through the meter on test and thence through one or more reference meters. The pressure is then dropped to the local distribution network pressure and the gas flow measured again and fed into this network for domestic consumption. The error curves of the reference meters are known and computer stored. The pulses from the turbine meters on test at a given flowrate is counted and compared with the signal from the reference meter and the error computed. The test room and gas temperatures are controlled to be the same so no heat is transferred from pipe to room. A Desgranges and Huot piston pressure weigher has just been installed to give a very accurate measurement and the piezo electric pressure transducers of the rig are to be calibrated and tested against this. The Laboratory ventilation system was of interest in that 15 changes per hour of air are provided and that methane sensors warn of low levels of escaping gas from the test lines and isolate the plant if predetermined levels are exceeded.

Density meters used in the distribution lines in association with turbine meters are also calibrated in the laboratory, temperatures of the meter are controlled by water bath and either pure methane or nitrogen is used at known pressure (deadweight tester) to calibrate in accordance with standard AGA 90.

Literature obtained:

Hoeks, C. P. "Legal aspects and traceability of High Pressure Gas Measurements in The Netherlands". Reprinted from "Flow Measurement of Fluids". Dijstelbergen, H. H., Spencer, E. A. (editors). North-Holland Publishing Co Ltd (1978).

NOTES ON A VISIT TO GAZ DE FRANCE, ALFORTVILLE, FRANCE
ON 1 APRIL 1983

Address: Gaz de France
Direction des Etudes et Techniques Nouvelles
3 Chemin de Villeneuve
94140 Alfortville
France
Tel (1) 375 57 57
Telex 620 334 GAZDETN PLDNI

Persons seen: Mr D Marque, Head of Metrological Services and Network Equipment

FACILITIES

Purpose: In a programme of research work decided in consultation with the G de F transportation and distribution departments, the laboratory exists to provide the necessary metrological and research support to ensure the accurate measurement of gas flows throughout the distribution network and to determine the suitability of pipework equipment that G de F proposes to install.

Brief description: The laboratory has two sites about a mile apart situated on an old gas works site, now largely re-constructed.

In the older of the two laboratory sites the largest laboratory building contains test rigs for checking pressure regulators, and the effect of velocity profile on gas turbine meters at flowrates up to 8000 m^3/hr (STP) at pressures from 20 mbar to 50 bar. A small high pressure rig is capable of testing valves up to 120 bar. All rigs are supplied with gas from the distribution line at the pressure required for the test. The pressure is either broken down by regulator or increased by gas compressors contained in a separate compressor house. The gas used during the test is led away to gasometers to be later used by consumers in the city. The reference standards of flow used throughout the laboratory are sonic nozzles calibrated in turn by the use of a large capacity of known volume in which the initial pressure and temperature at commencement of the flow through the sonic nozzle is noted and again at the end of the test. Both nozzle and capacity are immersed in a large controlled temperature water bath.

In smaller laboratories leading off this laboratory are contained rigs for measuring the noise of domestic gas meters which, for the tests, are contained in a small anechoic chamber. In a climatic chamber the starting torque V temperature characteristics of gas turbine meters are measured. Pressure and temperature transducers are calibrated against absolute standards (Degranges and Huot pressure standard).

For noise analysis comprehensive facilities consisting of tape recorder, signal analyser, calculator and plotter of Hewlett Packard manufacture are available. Microphones and other octave band analysers by Bruel & Kaer are used in the laboratories, whilst a further set of equipment for use on outside test work is also available.

Situated in a partially enclosed shelter pressure tightness test rigs are available for testing at temperatures between -20°C and +60°C.

Also situated in an open sided shelter is a dust test rig consisting of a loop of pipe work recirculating air through the valve or other device on test in which metallic oxide particles of different grades are added to the flow.

Two separate gas flow rigs having a bank of six sonic nozzles as reference flow standards with a flow capacity up to 10,000 m^3/hr are used for calibrating gas turbine flowmeters, and also for noise measurements and investigating the mechanism and laws of sound propagation in pipe systems. New test facilities for meter calibration and research situated about a mile away were completed in 1980 at a total cost of 8 x 10^6 French francs. Seven calibrated sonic nozzles are used as a flow standard and between these nozzles and the meter on test 50 m of pipework (80-300 mm Ø) is available as a meter upstream installation length. Flowrates up to 60,000 m^3/hr are possible at pressures between 300 mbar and 60 bar and the gas flow is temperature controlled (and heated by hot water heat exchanger and boiler if required) to 20°C. Because of the large flows the gas, after passing through the test section, is reintroduced to the distribution network at 1 bar pressure rather than being stored in a gasometer.

We were also shown a mobile laboratory which is used to calibrate gas flowmeters in situ. Hydrogen at a known rate is introduced into the test flow line and a sample of gas withdrawn some distance downstream, a comparison of the relative concentrations of hydrogen multiplied by the rate of its injection gives the flowrate of the gas flow.

Discussions with Mr Marque at the end of the visit established that the laboratory has a staff of about 30, 18 technicians and 8 engineers. The engineers, all drawn from other divisions of G de F, stay at the Laboratory for 3-5 years, whilst the heads of the technical staff stay longer.

Training of staff from Palghat would present no problem. G de F would make no charge for training, 3-4 months would probably be long enough and a subsistence allowance for the student of at least 25,000 Francs for 3 months would be needed at present day prices.

Enclosed with these notes are some kindly prepared by Mr Marque giving details of their research programme.

LITERATURE OBTAINED

1 "Research in Gaz de France - Current studies and achievements." Gaz de France - direction des etudes et techniques nouvells.

2 Direction des Etudes et Techniques nouvells du Gaz de France.

Alfortville, le 28 mars 1983

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Principal field activities of the department are the following.

1 - MEASUREMENT OF GAS FLOW

. Calibration of flow-meters at pressure going from 20 mbar to 50 bar (with sonic nozzles).

. Study of quick variations influences of flow on flow-meters.

. Study of position influence of the flow-meter in the network or in a pressure regulation station.

. Study of new equipments.

2 - STUDY OF NOISE PROBLEMS

. Influence of network particularities

. Study of noiseless regulators

. Study of silent equipments.

.../...

3 - PRESSURE REGULATION

. Experimentation of networks regulators, and regulators for boilers-plants.

. Trials from - 25°C to 60°C with gaz flow.

. Endurance trials.

4 - VALVES AND TAPS TRIALS

. Trial of all taps and valves and their motorisation to determine :

. their internal and external gaz-tightness

. operating torque

. influence of dusty gas

. working at - 25°C until + 60°C

. influence of condensations.

5 - OTHERS ACTIVITIES

. Filtration (freeing from dust) study of network filters low and high pressure.

. Trials of security equipments

. Discharge conditions in feeders

. Trials of breaking feeders detectors.

NOTES ON A VISIT TO FISCHER & PORTER GmbH, GOTTINGEN, GERMANY
ON 6 APRIL 1983

Address: Fischer & Porter GmbH
Postfach 701
D3400 Göttingen
Federal German Republic
Tel (0551) 905

Persons seen: Mr E Appel, Head of Product Research

FACILITIES:

Purpose: The test facilities had been set up to develop and test the company's products ie electromagnetic flowmeters, variable area, swirl and vortex type flowmeters.

Brief description: The company has 5 flowmeter test rigs of its own design. Three of the rigs are certified by PTB and all use PTB certified transfer standard meters, although one rig has in addition three volumetric tanks of standard design having capacities of 1 m^3, 100 l, and 20 l. PTB have certified the accredited rigs as being able to measure flowrate to within $\pm$0.2%. It was somewhat surprising to find that all the master meters used are magflowmeters and that they retain their PTB calibration for periods of about 1 year. The largest rig, largely situated in the open air uses a totally submerged axial flow pump to generate a flow of 5000 m^3/hr. The pump has a by-pass to regulate flow quantity and the rig is a closed loop but has a reservoir into which the circuit water can be dumped when changing meters in the test section.

A gas (air) test rig, sucks air through lengths of inlet piping to an exhauster situated in the cellar. Flow measurement is by critical nozzles, again certified by PTB, used for swirl meter calibration. Some customers ask for specified code products ie PTB approved when used for custody transfer applications and these are specially tested and approved. Customers for custody transfer meters are water distribution companies, breweries and to a lesser extent milk collection and distribution companies.

Brochures obtained: None

On the question of training, this was given to some large customer's staff but there may be difficulties. It was suggested that we should write to Mr Wilfried Kiene, Technical Director, if we wished to take matters further.

NOTES ON A VISIT TO SULZER BROTHERS GmbH, WINTERTHUR, SWITZERLAND ON 8 APRIL 1983

Address: Sulzer Brothers
CH 8401 Winterthur
Switzerland
Tel (052) 811122
Telex 896 165

Persons seen: Mr J R L Penney, Sales Engineer, Valves & Control Systems Tel. 052 813444

Mr F C Lang, Mechanical Engineer, Valve & Actuating Systems Design. Tel 052 818345

Dr U Bolleter, Head of Laboratory, Vibrations and Acoustics Research and Development. Tel 052 812123

Mr Schachenmann, Head Fluid Mechanics Laboratory

FACILITIES:
Purpose: An impressive array of research facilities dedicated both to long term development and to general service and consultancy. Very little of what we saw was directly product orientated although the purpose of the research is ultimately to improve their pumps, fans, compressors, valves etc.

Brief description: A complex air variable pressure test rig has been constructed in which a model compressor rotor can be rotated by a driving dynamometer (torque tube using moiré fringe techniques). The stator and guide vanes and scroll casing are also modelled and surface roughness can be simulated by glass beads added to the model surfaces. The rig has a pressure range of 0.3-30 bar which gives a range of R_e of 100:1.

A further vertical test rig for radial compressor research can use Freon, or air, and has a sophisticated torque measurement section mounted on hydrostatic bearings. The instrumentation for this rig uses a scanni valve for monitoring the pressure at the various places on the rig. Scanni valve only suitable for studying steady state conditions.

Cavitation research is in progress and a high pressure high velocity (60 bar, 100 m/s) cavitation rig has been built to study the effects of cavitation erosion on pump materials. The rigs use Perspex for some of the model windows but for high pressures ZERODUR a glass ceramic made by Schott, Mainz, W Germany is used to make windows and portholes.

The main pump model test facility has a large sump bridged with concrete adjustable beams and with fill in panels (see enclosed brochure). Pumps can thus be mounted on the lid of the sump for testing and their suction attached to a further inlet tank whose level can be adjusted for NPSH tests. Flow measurement at flowrates up to 1 m^3/s is by two venturies calibrated at NEL, United Kingdom, and at lower flowrates by a small volume tank. Pressure measurement is by deadweight testers (of their own design). The circuit diagram of this facility is given in the document referred to at the end of these notes.

Sound and vibration laboratories. Extremely well equipped laboratories in which research testing of all the company's products can be done eg looms, valve models etc. Anechoic and reverberation rooms are available but much work is done at customer's sites with mobile equipment taken there in a mobile laboratory.

Surprisingly most of the valve noise test work was being done on small brass models of valves and in air in the reverberation room. It was claimed that modelling laws were established which depend on Reynolds No, Mach No, geometry, and correlation with a site test of the actual valve.

All their equipment taken on to site is battery operated and nearly all supplied by Bruel & Kaer. A small seismic test stand capable of being loaded up to 600 kg having an acceleration up to 3 g and a frequency of 5-400 Hz is available and will be replaced soon by a larger version.

An acoustic test stand for mufflers was similar in concept to the one already seen at NEL.

Brochure obtained:
H Durrer. "The fluid dynamics laboratory".
Reprinted from 1970 Research Centre issue of Sulzer Technical Review.

In the matter of training, this was given to students (at a cost) and we should approach Mr Hintermuller the Training Manager. Mr Lang felt that a student could not live on less than 50 Swiss Francs per day subsistance allowance.