OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

RESTRICTED

15434

DP/ID/SER.A/709
20 June 1986
ENGLISH

DEVELOPMENT OF MICROPROCESSOR BASED AGRO-DAIRY INSTRUMENTS

DP/IND/81/025

INDIA

Technical Report: Development and Calibration of Infra-red Instruments in India *

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 C.A. Nexé
Expert in Infra-red Agro-dairy Instruments

United Nations Industrial evelopment Organization
Vienna

* This document has been reproduced without formal editing

V.86-57580

1. Aim of the work.

The purpose of my stay with the ESPL was to help them solving the calibration-problems involved in producing instruments for grain and milk, including theory of calibration, data-treatment and suggestions for standard-methods.

2. The Electronic Systems Punjab Ltd. to-day.

The ESPL company is a State Government owned enterprise of some 2oo people with a turnover of about 2o million US$ a year.

Their main product is computer-systems for the indigenous market, but they are also producing data-acquisition systems in collaboration with Westinghouse, USA.

3. Status of instrument upon arrival.

Upon arrival (after the usual delay of getting a permit to enter Punjab) neither the prototype grain-instrument nor the "Neotech lol" from which it has been copied would work. All efforts so far except training had been concentrated on the grain-analyser, whereas no work on the grain-milling-system or the milk-analyser had been carried out.

4. Activities.

4.1. Grain-instrument.

In order to make any progress I had to get the prototype to work. Therefore the first week was spent analysing the circuits of the prototype to find out what was wrong. This was not part of my task,

but I could achieve very little without a working instrument.

Eventually the problems were isolated and solved by minor modifications.

4.2. Training of personnel.

Three persons of the project group were available for training:

Mr. V.J. Puri (Deputy Manager)
Mr. M. Chakraborty (Optical Engineer)
Mr. Meharban Singh (Electronic Engineer)

the others being abroad for training.

Apart from explaining the electronics of the Neotech 101, a training program including all aspects of calibration and basic infrared theory was held. The topics are listed in Appendix I.

Most of the information was also supplied in written form.

The persons involved seemed to have an excellent basic training allthough they naturally have limited experience in the specialized field of infrared instruments for the food industry.

4.3. Calibration of grain-instrument.

22 wheat samples were ground in the cyclone mill and measured by the prototype-instrument.

Unfortunately we did not receive the chemical standard-values from the Agricultural University of Ludhiana before I left, but the project-group was very carefully instructed about the use of the computerprogram necessary for the calibration.

A numerical example was given and tried out by them.

As the results arrive I will receive a copy in order to check them.

If further assistance from technical experts should become necessary calibrated samples must be available in advance in order not to waste too much time.

If the ESFL are to have their own calibration instruments in the future this problem will be partly eliminated.

5. Estimate of ESPL capabilities.

The ESPL is - in spite of being government owned - a very efficient company.

They have a well educated staff, but their major drawback as compared to American or European companies is that they have very limited possibilities to have mechanical parts made. Furthermore the supply of parts that industrialized countries take for granted is also limited in India. Consequently a number of parts have to be imported which is time-consuming and expensive.

I think the company eventually will be able to produce grain- and milk-instruments to suit the third world market because of their cheap labour, but an export to European countries or the USA will take many years from to-day.

6. Recommendations on further activities.

6.1. Suggestions for improvements and simplifications of grain-instrument.

In order to make the instrument better and cheaper a number of changes were discussed with the project-group. These are listed in Appendix II.

Some of the changes will also distinguish the instrument from the "Neotech lol".

6.2. Proposals for milk-instrument.

Since no work has been carried out on the milk-analyser yet we discussed the possibilities of making such an instrument.

First of all the present instrument could not be used for milk-analysis with any reasonable accuracy.

The minor changes suggested in Appendix III to make a cheap instrument for Fat and Total-Solids could be implemented.

It would be necessary though to find out if an instrument like that

has a potential market and to prove by a pre-investigation that the Total-Solids accuracy would be sufficient.

If not a cheap single-beam instrument measuring Fat, Protein and Lactose is suggested. This would probably have to be in collaboration with a foreign company.

6.3. Instruments for standard-methods.

It is my impression that a chemical standard-laboratory as such is beyond the scope of the TSPL. Establishing such a laboratory would take years, and the final accuracy would have to be checked against other standard-laboratories doing ring-analysis between them. Also the chemical methods are very time-consuming.

I therefore recommend the use of fast automated standard-methods which take very little training to operate and which will give better repeatability and in many cases better accuracy because the operator-errors are minimized.

In some cases indirect methods are used since they provide sufficient accuracy. Appendix IV has a list of suitable instruments.

With grain the standard methods are used except for moisture which can be determined accurately by the dielectric method, if each sort is calibrated seperately.

For milk I suggest a simple manual infra-red instrument which may be checked from time to time against Gerber for Fat using standard-samples from an agricultural university. Protein may be checked against Kjell-Foss.

It should be noted that most users of these instruments would fine-calibrate their instruments anyway not trusting the factory calibration entirely.

N. Foss Electric of Denmark is suggested as a supplier of instruments because I am familiar with their products from a previous employment with them.

Certainly other manufactures exist and could equally well be used.

It should be stressed though that a company with service facilities in India is essential. (N. Foss Electric has an office in Bombay).

Also local training in the use of the instrument is important.

6.4. General instruments.

In time it will be necessary to have a spectrometer in order to obtain reference spectra on new samples and also to check the optical filters of the instruments produced. It should be decided first however in which wavelength-range the milk-instruments will operate since most commercial spectrometers are divided in two groups of the infra-red spectrum:

either the near-infra-red instruments ranging from approx. 1 to 2,5 µm

or the mid-infra-red from 2,5 to 25 µm.

Ideally the instrument should cover from 1 to 12 µm, but I do not believe such an instrument exists.

6.5. Possible collaboration with other companies or institutions.

There are three major problems involved in producing infra-red instruments for quantitative determination of constituents in food:

6.5.1. The manufacturing of optical interference-filters of sufficient quality and at a reasonable price.
The quality is no problem to-day since several European and American companies are able to produce them.
The cost is not very likely to come down unless huge quantities are produced. Bearing in mind that optical filters to-day are the major contributors to cost price of these instruments, the only way to decrease this price will be to produce filters in India.
I believe a project for thin-film-coatings has been started up nearby, but I have not been able to find out in which state the project is presently (IN/DP/79/046).

6.5.2. Obtaining samples of sufficient variety.
This is essential for the calibration of grain instruments where statistical methods must be used whereas milk-samples to some extent may be changed by mixing samples and adding constituents. Consequently a close relationship with farmers associations and/or agricultural universities is a must.
I believe the ESPL already has some collaboration with "The Agricultural University of Ludhiana" apparently not officially, but on a personal basis.

6.5.3. Special mechanical parts:

Infra-red instruments especially the milk-apparatus do have a number of critical parts in them which require special know-how and fine-mechanical facilities. I am referring to optical-cells, high-pressure-pumps, homogenizers, choppers, filter-shift mechanics, cyclone-mills etc. These items cannot be made by ESPL at present, and some of them will be difficult to have produced in India.

Therefore on short term basis the ESPL may be better off if they collaborate with a company having the necessary knowledge and maybe purchase some of the critical parts of them in the beginning. Foreign companies would probably only agree to this provided the indigenous manufacturer would limit his market to India or possibly third world countries.

N. Foss Electric of Denmark whom I used to work with has had such arrangements in India and may be willing to do this again.

7. Summary.

I hope my work with the ESPL will help them to get their project finished as soon as possible and that there will be sufficient funds to get the instrumentation necessary.

Furthermore I will be willing to supply the company with technical information as the need arises in the future.

It was virtually impossible to bring all technical information along so I had to concentrate on the main subjects which are well covered by the litterature left with the company.

A list of additional information which I will send to the ESPL from Denmark has been made.

Appendix I

TRAINING PROGRAM DURING MR. S.A. NEXØ'S VISIT TO ESPL

Mr. S.A. Nexø is visiting our Company (ESPL) from 19.5.86 to 6.6.86 as an expert in calibration of Microprocessor based NIR instruments. During this period he will train the UNDP Project personnel on the following topics:

1. CALIBRATION OF INSTRUMENTS.

   i. a. Calibration theory for milk-analyser.
      b. Calibration for grain-analyser.

   ii. a. Calibration procedure for milk-analyser.
      b. Calibration procedure for grain-analyser.

   iii. Multiple linear regression analysis, comparing standard-methods against instrument results.

   iv. Standard-methods for milk and grain analysis.

2. INFRA-RED COMPONENTS.

   Infra-red sources, optical reflectors, lenses, concentrators, monochromators, optical cells, choppers, detectors.

3. INFRA-RED INSTRUMENTATION TECHNIQUES.

   Double beam, double wavelength, double cell, single beam.

4. POSSIBLE IMPROVEMENTS AND SIMPLIFICATIONS OF DESIGN FOR THE GRAIN ANALYSER.

5. DESIGN SUGGESTIONS FOR MILK ANALYSERS.

6. SUGGESTED INSTRUMENTS AND EQUIPMENT FOR PRODUCTION CALIBRATION OF GRAIN AND MILK ANALYSER PROTOTYPES.

SUGGESTIONS FOR IMPROVEMENTS AND SIMPLIFICATIONS OF GRAIN INSTRUMENT.

1. Use 5 more wavelengths in the equations to include oil and dual references. This will decrease drift and dependency of milling and thereby give better accuracy.

2. Use flexible software so that pulse count and absolute wavelength will not have to be the same between instruments. This will provide more accurate adjustment on absorption peaks, and the filter specifications may be relaxed.

3. Better compensation for surface-effects could be obtained by using 4 detectors rather than two, by rotating the sample, or by inserting the sample from both sides of the instrument.

4. The encoder should be redesigned to become less critical.

5. All hold-capacitors should be polycarbonate rather than electrolytics.

6. Switch-mode capacitors should be low self-inductance types.

7. The light-source could be a standard-type with no reflector and the beam divergence of the parallel light beam could be increased to give more light-power. Using a nominal 6 V lamp it could be powered from the logic + 5 V supply.

8. The peltier-coolers could be omitted to save a substantial amount of money. The only disadvantage is that the noise from the detectors will increase, but according to No. 7 this will easily be counteracted. The log-amplifier would have to be temperature stabilized, but this could easily be done by a chip-oven circuit using very little power.

9. The -190V Supply could be replaced by the -15V supply. The signal would be approx. 5 times smaller, but since we are detector-noise-limited the signal to noise ratio will be the

same provided the -15V is filtered properly.

10. All supply voltage could come from the pre-regulator supply of +14V. If a 6V motor is used only +5 and ±15V is necessary.

11. It would simplify the instrument if compensation for no light and log-conversion is carried out by software.

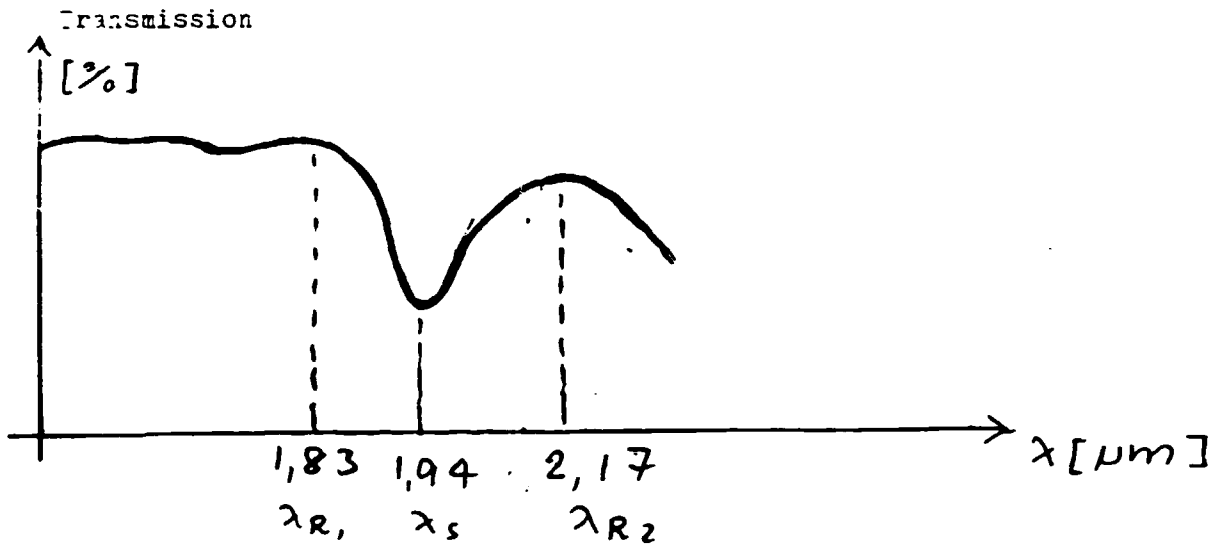
PROPOSAL FOR CHEAP MILK ANALYSER MEASURING FAT AND SOLIDS NON FAT.

The main cost of an IR-milk instrument as they are produced to-day is the IR-filters: two per component each costing around $ 120.

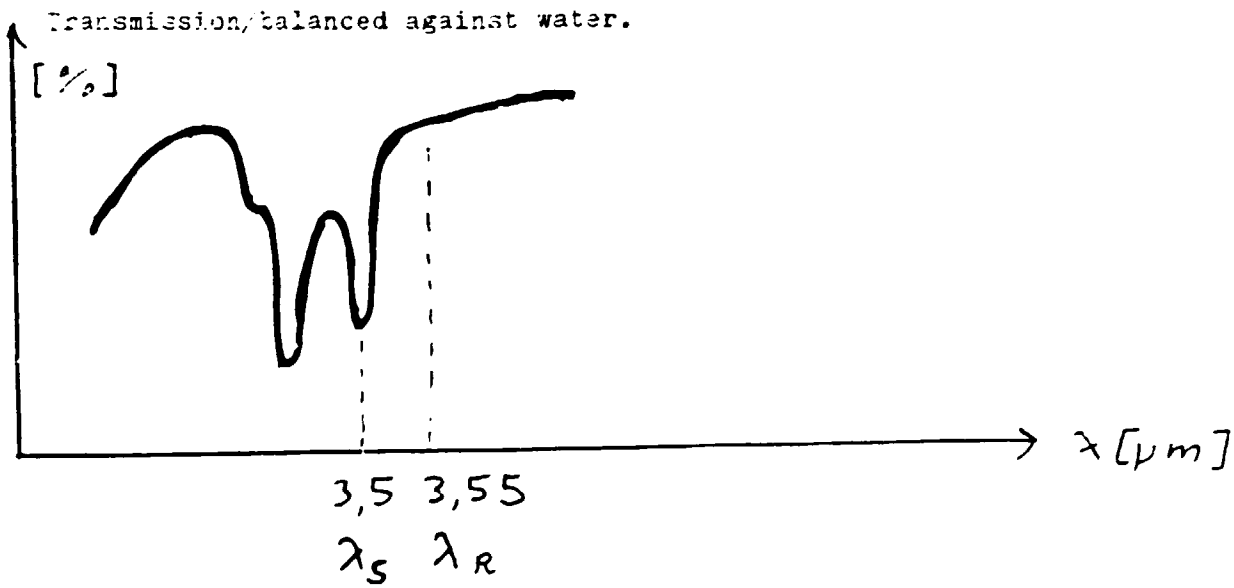
One way of decreasing this cost is to use the technique of the grain analyser with two rotating filters at 2,0 and 3,55 micro-meter center-wavelength. The detector would have to be PbSe rather than PbS to extend the wavelength-range to 3,55 micro-meter, but the optics (light source + lens) could remain the same. The software would also have to be changed slightly. The energy resolution necessary is about 1:2500 for fat with a repeatability of 0,01% fat and 1:4500 for solids non fat with a repeatability of 0,03% SNF. This is somewhat more demanding than for the grain analyser, but the dynamic range is less.

From previous experience it is known that fat can be measured with sufficient accuracy at 3,5 micro-meter using 3,55 micro-meter as a reference, but whether the 1,94 micro-meter water absorption band will provide the accuracy necessary is not quite certain. Also it will have to be checked if the 3,55 micro-meter filter will give enough range as it rotates, (I will send information from Denmark). It should also be investigated whether an instrument with fat and SNF only has a large market in India or in the third world.

If these conditions cannot be met, I will suggest to make a simple single-beam-no-mirrors system like the Foss Milcoscan 133 possibly with the collaboration of N. Foss Electric. An instrument like this will have a cost price of approx. 550 $ more than the simple two filter instrument, but it is more versatile giving both fat, protein, lactose, Solids Non Fat and Total Solids read outs. Thus, the market potential will be far greater which may compensate the higher cost. Estimated cost price $ 2500 in India.



Water absorption at 1,94 μm if possible with two references.



Fat absorption at 3,5 μm (CH_2-bond) "Fat 3".

Appendix IV

LIST OF EQUIPMENT SUGGESTED BY MR. NEKS FOR CALIBRATION

		Address	Approx. Cost
i.	Kjell-Foss Automatic for protein measurement	A/S N. Foss Electric 69, Slangerupgade DK-3400 Hillerod Denmark	$ 24,000.00
ii.	SUPER Matic 10 for Moisture measurement in grain	- do -	$ 8,000.00
iii.	Fosslet (Soxhlet Std. Method)	- do -	$ 9,000.00
iv.	Commercial Infra-red Milk Analyser manual mode	- do -	$ 23,000.00
v.	Electronic Balance	Oertling Limited Orpington Kent BR5 2HA England	$ 3,000.00
vi.	Near Infra-red Spectrophotometer Range 1-2.5 /µm Dual beam mode Transmission accuracy = 0.1% Resolution = 2 nm With X-Y Plotter and computer	(a) Perkin Elmer Corp. Norwell, Connecticut USA (b) Neotec Instruments Division 2431, Linden Lane Silver Spring MD-20910 USA (c) Trebor Industries Inc. P.O. Box 2159 Gaithersburg MD 20879 USA	$ 15,000.00