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NATIONAL CANE SUGAR INDUSTRY RESEARCH CENTRE

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CHINA .

Technical report: The Use of Microcomputers in the Field of Management and Process Control of Canesugar Factories*

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

Based on the work of Dennis Forder,
Expert in the use of microcomputers in management and process control

United Nations Industrial Development Organization
Vienna

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1. INTRODUCTION

1.1 Objectives

The objectives of the visit as outlined by UNIDO's job description were (1) to furnish practical knowledge and experience on the application of microcomputers in the field of management and process control of canesugar factories (2) to draft an efficient project on computer application research work which will be undertaken by the National Canesugar Industry Research Centre.

1.2 Form of the Project

The objectives were to be met by presentation of lectures on recent developments of computer application in canesugar factories and lectures on computer-based research that could be applied to process simulation/feasibility of the various canesugar processing areas - extraction, clarification, evaporation, boiling - and also applied to factory management. The lecture topics were arranged by the Automation Group of the Guangzhou Sugar Cane Industry Research Institute and the lectures were to be given at the Institute.

1.3 Summary

The objectives of the project were, in general, achieved. The Recommendations section of this report describes a structure within the National Research Centre which would provide a computer-based research environment for canesugar processing and factory management and also provide administrative/management facilities for the Research Institute.

The control processes in factories are generally quite straightforward but although the ends to be achieved in China and Australia would generally be the same, the means are often quite different. Thus current applications in Australia were given as examples of what could be done rather than how they were done. Documentation was provided giving various examples of computer controlled processes in Australian sugar factories and the techniques and equipment used were then described in lectures covering general principles of computer-based process control.

The staff at the Institute proved to be attentive and keen to participate in the lectures/discussions and helped the author to form some basic understanding of conditions in China for research and, to a lesser extent, in the sugar factories. For the latter, the author has drawn heavily upon the excellent report produced by Dr. M.A. Clarke (29/5/84) for understanding of the Chinese Sugar Industry in forming some of the recommendations.

Finally it must be said that the generosity and hospitality of the Institute staff (and others) was such that the author found it a pleasure to work and that throughout his stay in China he was made to feel most welcome.

2. ACTIVITIES

The activities undertaken during the project were organised by the Automation Group of the Institute under control of Mr Ye Jiangang and comprised:

- visit to ZINI sugar factory
- lectures at the Institute
- lectures at Automation Congress
- discussions with staff at the Institute

2.1 Visit to ZINI Sugar Factory

The Sugar Factory at ZINI has two computer control projects in operation and a further project under development. Unfortunately, due to delayed start of the project, the cane crushing season had finished and the factory was not in operation. However, the author was able to inspect the computer control centres and the operation of each process was explained.

The first project covered control of the evaporation process and was developed by the Automation Group at the Institute. The factory manager appeared satisfied with the results of the project which provided much tighter control of the desired Brix value and evaporator levels.

The second project covered control of the sugar boiling process and was developed by another research institute. Again the factory manager appeared satisfied with the results of the project which provided better quality, more consistent sugar. The latter development project, in fact, is to be extended to link each of the individual boiler processes to a central computer to provide supervisory control. No information on progress of this development was provided.

After inspection of the factory at Zini, some aspects of cane receivals were discussed. The problems of accurate weighing were of particular concern to the factory manager as the (two) weighbridges were suspended some height above the riverside delivery points and exposed to wind effects.

The current procedures for simultaneous loading from separate cane shipments would need to be changed if automated tracking/testing were to be introduced at the factory, and again highlighted the differences between China and Australia as in Australia the normal mill train method of cane delivery lends itself to automatic tracking procedures.

2.2 Lectures

2.2.1 Automation Congress

The South China Automation Congress was being held during the visit and the author was invited to present two lectures "The Current Use of Microcomputers in Process Industry" (full day) and "The Current Use of Microcomputers in Business Management" (half day).

The author presented a wide range of developments of the use of microcomputers in industry and business and gave brief descriptions of typical projects in which the author had been personally involved.

2.2.2 Guangzhou Cane Sugar Industry Research Institute

Lectures at the Research Institute covered the operating environment of the DUAL 68000 and included various aspects of the UNIX operating system and the associated software development facilities. Due to problems with installation of the computer system it was not possible to demonstrate any of the features by use of the computer. However, practical demonstration on the configuration and use of the "intelligent" terminal - Televideo 914 - was provided.

Other lectures included those on the methods of (software) project development and detailed examples of projects which demonstrate the various aspects of process control.

2.3 Discussions

Discussions were largely informal with the main benefit of providing the author with valuable insights into the differences between sugarcane production (and process computing in general) in China and Australia. The author also spent some time in attempting to establish the structure of the Institute, the use of computers within each section of the Institute, and details of computer-based projects both completed and under development at the Institute.

3. OBSERVATIONS

3.1 General

The overwhelming impression gained by the author is the vast difference between Australia and China in the means of achieving the same ends of improved sugar production using computers. Given that a factory in each country would aim to increase production of higher quality sugar at the lowest price, the methods of achieving this aim vary dramatically.

Choice of Computer

In Australia most of the major manufacturers of process control computers and general purpose computers are directly represented. This provides a wide choice for selection of the most appropriate computer system for a particular application at the best cost effective price. In China the local choice is quite limited (although improving) and the restricted availability of exchange currency for import of foreign goods also limits the availability of computer equipment. Thus whereas in Australia, computer systems are readily developed from the standard microprocessor board level, in China it is frequently necessary to start at the chip component (relatively cheap cost) and build to the board level - a very time consuming function and requiring highly-skilled engineers.

Choice of Instrumentation

As with the choice of computer, in Australia a wide range of transducers, signal conditioning equipment, and instruments which directly link to computers is available. Thus the computer to factory instrumentation interface can be readily developed from standard components. In China, again the choice is limited and frequently the instrumentation interface has to be developed from the chip level combined with special engineering for instrumentation development.

Process Control Criteria

Assuming "more, better, cheaper" are the sugar factory production aims, then the higher level control strategies can be quite different from factory to factory and certainly are from country to country. Between Australia and China this is demonstrated in three main areas:

- energy usage. In Australia, manufacture of particle board is able to take advantage of the well developed wood chip industry. Thus the bagasse in Australia can be used as a very cheap fuel for factory boilers and keep energy costs to a minimum. In China, because of the lack of forestry and associated industry, use in making particle board and (relatively expensive) coal is required for the major supply of factory energy).

- staffing levels. In Australia, the high salaries mean that staffing levels are an important economic consideration for factory operation. In China, the lower salary levels make this less so, and the political/social objectives in China are towards maintaining full employment rather than restricting it in any way.

- time scale. As with staffing levels, in Australia it works out cheaper to buy ready-made microprocessor boards rather than develop from the chip level. In China the direct costs are less to build from the chip level, however the time-scale of projects is proportionally lengthened by the time taken for the hardware development. This will ultimately limit the speed of computer development in the sugar industry and would appear to be one area where direct costs should not be used as a measure of economic advantage.

Software vs Hardware

The research projects undertaken at the Institute have generally required significant hardware development for reasons outlined earlier, with much less emphasis placed on the associated software which has generally been that for a dedicated process control function. Software development becomes much more significant for systems providing factory supervisory control and management functions. None of these systems have yet been implemented in sugar factories in China and thus acquisition of the latest microprocessor technology for hardware development is still seen to be the most important area of educational development. Whilst it is important to be aware of these developments, the author considers it equally important to develop the software skills required for development of factory supervisory control and management functions as experience in Australia and elsewhere has shown these to be areas where significant advantages can be gained in increased production, quality and costs.

Power Supply

It was noticeable that the electrical power supply at the Research Institute was quite erratic with many interruptions to the supply. A standby generator was available at the Institute in case of a major interruption. When commissioning the management computer at the Institute, a special supply to the computer had to be provided to meet the strict electrical requirements relating to voltage and cycle variations.

Education

The staff at the Institute appeared highly-skilled but also highly specialised, with little cross-discipline activities. Computer software skills appeared to relate solely to the dedicated sugar process functions which only required limited software development facilities. Practical skills relating to general purpose computing functions for definition and development of larger computer systems did not appear available.

The library provided an excellent range of technical literature covering worldwide activities in all aspects of sugar research.

3.2. Cane Sugar Research Institute, Guangzhou

3.2.1. Structure

Departments and their associated functions are as follows:-

- Automation Department

  * Research/Development of automation in sugar factories
  * Development of computer-based projects for sugar factories
  * Development of special instruments for use in sugar factories

A variety of computers are available for general use in the department and a number dedicated to specific research projects. They include: Apple II, TMC 80 (Z80-based), ZD065 (6502-based).

- Sugar Processing Department

  * Research into extraction, clarification, boiling

Research into sugar technology by development of process models and specialised instrumentation. TMC 80 microcomputer used in boiling research project.

- By-Product Utilisation Department

  * Research into particle board manufacture from bagasse
  * Research into treatment of waste-water from factory
  * Research into fermentation/alcohol production
  * Research into stillage/cattle feed
  * Consideration of environment protection requirements

  No computers are in use for this department

- Analytical Department

  * Sugar juice testing - organic and inorganic

  Two Apple II computers available for analysis of test results.

- Agriculture Department
  * Research into cane breeding

  * Research into agronomy/fertilisation techniques
  * Research into plant protection/weed and pest control

  Sharp 1500 PC available for analysis

- Technical Information Department

  * Library of local and overseas technical literature
  * Monthly production of in-house magazine - separate agricultural and industrial editions. Ad hoc special editions of particular topics of interest.

  No computers in use at present but awaiting delivery of an IBM PC which has been provided by the Ministry of Light Industry.

- Workshop

  * Services to the other department for supply of tooling and manufacture of special equipment.

- Administration

  * Employment
  * Housing
  * Education (internal and overseas)
  * Finance/Accounting
  * Supply
  * Canteen

  No computers in use at present but expected that some administrative/management functions will be computerised using the DUAL 68000 system.

3.2.2. Computer-Based Projects

A number of computer-based projects have either been developed or are under development at the Institute. They include:-

- Evaporator Control

  This project was developed for the sugar factory at Zini by the Automation Department. Brix and evaporator level desired values are maintained by a TMC 80 microcomputer which also monitors alarm levels and provides a printout of results on demand. The project has been successful with good Brix control.

- Production Reporting

This project is nearing completion and will be used for data processing of production details from all sugar factories. The data will be keyed into the computer which will perform analysis/calculations to produce a number of reports. These reports are printed with chinese characters using a special computer interface board and are to be further analysed by the Technical Information Department and typed reports distributed to factories. The reports are intended to provide factory management with a decision-making tool for individual factories and the means of information interchange between factories.

- Cane Receivals

This is a multi-stage project for tracking and testing sugar cane quality for a particular farmer. The first stage uses a Sharp 1500 PC linked to a Visual Display Unit (VDU). The display shows the tracking of cane from a particular shipment (farmer) and data is keyed for weight as it is read from the scale. The quality of the sugar juice is manually tested and the results also keyed into the computer. A strip printer provides a record showing farmer/cane type/weight/quality and provides the means of payment to farmers - by weight at present but possibly by quality in the future.

The next stage of the project will replace the manual testing of sugar juice by automatic means using a brix testing instrument under development at the Institute. Other stages include automatic capture of cane weight by linking the computer to the weighscale.

3.2.3. Management Computer

UNIDO have provided a research and management computer system for the National Cane Sugar Research Centre. The computer is a DUAL System 83/80 supplied by Advanced Microtron Co. Ltd. of Hong Kong with the following hardware configuration:-

* Motorola 68000 16-bit processor
* 512 Kbyte memory
* 80 Mbyte Winchester hard disk
* 1 Mbyte diskette
* Serial input/output for 8 terminals
* Variety of process input/output interfaces
* 5 x Televideo 914 VDU/KB
* Printer

System software supplied with the computer comprises the UNIX Version 7 operating system and associated software development utilities - text editors, compilers etc.

The computer system appears well suited to provide both an effective management tool and also the required research facilities at the Institute. The multi-user UNIX system will provide a department its own, independent computing facilities but with these able to be integrated into a centralised management function. Currently only five terminals providing access to the system are available, however the computer can be expanded to cater for another four terminals. The computer can also be expanded by addition of memory (up to a maximum of 3.25 Mbytes) and another 80 Mbyte mass storage device. Thus the system should provide sufficient capacity and growth path to meet the Institute's developing needs for computer management facilities.

A number of software packages are available for the computer system providing further management tools such as word-processing, accounting and spreadsheet analysis.

The computer system also provides facilities for research into computer controlled sugar factory processes. Software can be developed to simulate a process and then tested with the "real world" instrumentation via the variety of analog and digital input/output interfaces that are available.

The facilities offered by the computer require a higher level of software design and associated software development skills than appears to be immediately available at the Institute. Computer-based projects to date have generally been more concerned with the special engineering requirements rather than the programming requirements which have been relatively small and specialised. Thus a substantial learning/training period can be expected before full advantage of the powerful computing facilities can be taken.

Support facilities for the equipment are provided from Hong Kong at present although the manager for Advanced Microton indicated that a support centre was to be set up locally some time in the near future. As indicated earlier in the report, a steady, reliable power supply is vital for development needs and to keep (costly) hardware maintenance support to a minimum.

3.3 Sugar Factories

The author was only able to visit one sugar factory, during the project but subsequent discussions indicated that the functions and level of processing capability were typical of the 50-100 sugar factories using some form of computer controls. Processes controlled by computer were mainly the evaporation and boiling processes although other projects are under development for control of other sugar factory processes. Many different institutes appear to have been involved in developing (independently) basically the same process control systems using many different computers. This would appear to be a very inefficient use of the limited resources available for system development.

At Zini, the computer systems controlling the evaporation and boiling processor were developed by different institutes and both provided satisfactory results. The plant operator control panel was of the older style mimic panel with meters for display of process parameters and banks of lights to indicate alarm conditions.

4. RECOMMENDATIONS

4.1 Centralised Research Facility (Research Centre)

In line with recommendations from previous reports, it is also recommended here that the Research Institute through the Department of Light Industry, be established as the central control point for all sugar industry project development. Other institutes would maintain their research activities but these would be co-ordinated through the Research Centre.

The current situation where separate research institutes are simultaneously engaged in almost identical research projects leads to a very inefficient use of resources, both people and equipment. The information exchange obtained by the various seminars for Cane Sugar Technologists provides some informal means of avoiding duplication of effort, but a formal process with centralised control must be established if maximum utilisation of resources is to be obtained.

The Dual System 83/80 computer recently supplied to the Research Centre would provide adequate computing facilities in the shorter term to support the liaison and management functions necessary for a central research facility.

4.2 Computer Data Centre

To support the centralised research facility it is recommended that a computer data centre be established. The data centre would provide computing facilities for the following functions:-

- Financial and administrative management of the Research Centre
- Centralised collection/distribution of sugar research data for all institutes
- Research in management and control of sugar factories and processes

In the short term the Dual System 83/80 could provide the computing facilities for the Data Centre. Initially the Data Centre should be set up and administered under control of the Automation Department as they appear to have majority of computer-related skills at the institute. However, as the centre was developed the Automation Department will become just one of the users of the Data Centre and it will be necessary to find staff with appropriate management and support skills for the Data Centre.

4.3 Program of Development

It is recommended that development of the Data Centre is undertaken in a number of stages as follows:-

(a) Rationalise the Research Institute computing functions

At present, departments at the Institute are independently developing software on a variety of computers for their own research discipline. There appears to be little co-ordination between departments and no formal standards of data presentation. It is recommended that the Data Centre provide a software development service to all departments as this would provide a number of benefits:

- Scientists/engineers would be working in their own field of speciality and not having to learn unnecessary computing skills i.e. sugar research would be separated from computer engineering/software with the computer just another tool for the research scientist.

- The proliferation (and cost) of different types of computers would be avoided.

- The level of specification required to provide the software development service would force the research into a more structured and controlled standard

(b) Develop Sugar Process Modelling Facilities

The Dual System 83/80 has various process input/output interfaces which can be used to emulate sugar factory processes. The work currently undertaken by the Automation Department could be emulated at the Data Centre independent of the target computer to be used in the factory. This would require development of emulation software and external test equipment for the standard sugar processes. To minimise development time of processes, it is suggested that the approach adopted in Australia in a number of cases, for example the PPC described in the Appendix is also adopted at the Data Centre. It is also recommended that target computer systems are rationalised to minimise software conversion effort from emulation to "real world".

(c) Develop Sugar Factory Model

At a high level, sugar factory design to meet a specified performance can be determined by well-established formulae. The process can be parameterised so that various aspects of factory performance can be investigated by selection of appropriate values. The system parameters are known for operational factories and the model would help to identify and fix problem areas in the factory.

At a lower level, optimised control of a factory can be obtained by feed-forward control techniques e.g. adjusting evaporator levels to match mill fluid output and hence energy saving.

Optimised control features would vary from factory to factory but generalised processes could be developed and applied for factory emulation.

(d) Develop Databases

To support the centralised Research Centre and provide management facilities for the Institute, a number of databases would need to be developed. They could be set up by use of a database development package (available for the Dual 83/80 but not supplied to the Institute) or by special development at the Data Centre. Given the inexperience of the current staff in large computer systems, the former is recommended but it is recognised that economic considerations may not allow this approach.

The database would cover:-

- Administrative and management records for the Institute
- Research records for departments of the Institute
- Research records for all institutes.

4.4 Support Services

Support services cover primarily those provided by the Data Centre

- Software Support
- Training

4.4.1 Software Support

This would be a service to users of the Data Centre and covering three main areas:-

- support in systems programming aspects of UNIX and the UNIX-supported language processors
- support in software aspects related to control processes including emulation and use of test equipment
- support in proprietary software packages that may be obtained e.g. data base software

4.4.2 Training

Training is required both external and internal to the Institute. Data Centre support staff need to have access to the latest overseas software developments in order to provide adequate internal training in the software areas described above.

As well as training in those specific areas, training in methodologies of software development should also be provided by the Data Centre. The technical library will also need to be expanded to cover more general-purpose aspects of computing rather than those related solely to sugar and associated topics.

5. MISCELLANEOUS

5.1 Lecture Topics

- Microcomputers in Industry (Congress)
- UNIX : Overview, File Strucutres
- Microcomputers in Business (Congress)
- PPC : Components, Development, Run-Time Facilities
- UNIX : Shell command structure
- UNIX : Editors
- Demonstration : Televideo terminal set-up features
- Project software development methodology
- Examples of author's process control projects

5.2 Technical Documentation Provided

- Motorola Single Chip Handbook
- Motorola 8-bit Computer Handbook
- FOX3 Process Control System Description
- Articles from Proceedings of Australian Society of Sugar Cane Technologists
  * A Microprocessor-based Central System for Sugar Industry Applications
  * Supervisory Optimizing Control
  * Steam Balance by Supervisory Control
  * Controllers - Microprocessor or Hardwired
- Review of Computer Applications in Raw Sugar Manufacture
- PPC Overview
- Numerous back issues of "Control Engineering"
- Numerous back issues of "PACE" [Process and Control Engineering]

5.3 Project Management/Implementation Approach

5.3 PROJECT MANAGEMENT/IMPLEMENTATION APPROACH

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May, 1965

1. INTRODUCTION

2. ICS RESPONSIBILITIES

3. CLIENT RESPONSIBILITIES

4. PROJECT MANAGEMENT

5. CONSULTING PROJECTS

6. SYSTEM DEVELOPMENT PROJECTS

Stage 1 - Preliminary Study
Stage 2 - External Specification
Stage 3 - Internal Specification
Stage 4 - Code and Test
Stage 5 - System Integrate and Test
Stage 6 - Installation and Commissioning

1. INTRODUCTION

Industrial Computer Systems is primarily involved in the provision of consulting and computer systems development services. Since 1978, a wide variety of systems have been developed with particular emphasis on industrial applications using mini and micro computers.

In addition to providing professional services, ICS has also developed a number of software tools and products and has established purchasing arrangements with computer hardware and software suppliers. Through these arrangements, a "turnkey" systems approach is possible where ICS is able to select and supply the necessary hardware and software products as part of a total solution to meet a particular set of requirements.

A standard approach to consulting and systems development projects is used incorporating a sequence of clearly defined stages where completion of the activities performed in one stage provides the base for the next stage.

Each of these stages is described below.

Additional information on ICS Commercial Terms is available in "Optional Commercial Terms" and "Terms and Conditions of Business".

2. ICS RESPONSIBILITIES

Each assignment undertaken by ICS is treated as a project. A project manager will be appointed who will be responsible for co-ordinating those areas of the project relating to ICS, and for liaison with other project managers in periodic meetings. When ICS has major project responsibility, project meetings will usually be held not more than two weeks apart to keep the client informed and to co-ordinate joint responsibilities.

In areas relating to client responsibility, ICS will inform the client of his obligations and shall have the responsibility to ensure that the client is given sufficient time to discharge them without hindering the project implementation.

3. CLIENT RESPONSIBILITIES

The client shall provide a single person as project contact for the duration of the project, to attend and participate in project meetings. The person shall be sufficiently skilled and experienced in the client's requirements to make meaningful contributions, and shall have sufficient authority to make technical commitments on behalf of the client.

It shall be the responsibility of the client to ensure that decisions and actions relating to the project, and which have been agreed are the responsibility of the client, are carried out promptly and without unreasonably delaying the project.

Unless otherwise specified, the client accepts that the standard systems development approach will be followed and that no modifications, in particular no omissions, will be allowed. Each of the documents produced will be considered by the client as promptly as possible, and agreed to before further work can proceed. Of particular importance to the project is consideration of the Detailed External Specification which is the foundation document for systems development projects. The client acknowledges that this document fully describes his requirements and that any modification following this acknowledgement may result in increased effort and project slippage.

4. PROJECT MANAGEMENT

A project team to implement the system is set up covering both administrative and technical areas.

- The Project Manager is responsible for liaison with the client and administrative supervision.

- The Project Leader is responsible for setting and maintaining the project schedule and technical supervision.

Both the above are nominated at project commencement and remain until project completion.

- Other members of the team cover the technical design and implementation of the system.

The Project Leader reports to the Project Manager at regular intervals (usually weekly) with regard to current project status and progress against schedule.

Regular meetings are held (usually fortnightly) at which the Project Manager reports to a client representative. It is expected that the representative is nominated at project commencement and remains until project completion.

A written report is produced covering discussions held at the meeting with actions minuted and any changes to requirements clearly indicated. All correspondence is between the Project Manager and the client representative; it is their responsibility to direct information appropriately.

Regular project monitoring and reporting ensures that possible problem areas can be anticipated and guarded against before they become real problems, and that solutions for real problems can be considered with sufficient time for all options to be fully explored.

Where a turnkey (hardware and software) system is being provided, coordination and control of various hardware suppliers is maintained and interfacing requirements resolved.

Setting up project teams as above with the associated reporting and coordination functions ensures that project implementation is straightforward and under normal circumstances remains within expected cost and time constraints.

5. CONSULTING PROJECTS

ICS may become involved in a potential computer application at an early planning or feasibility stage. In these situations a consulting project may be established with ICS resources being used to assist the client in evaluating technical feasibility, identifying alternative approaches and assessing cost/benefit aspects.

Important aspects of a successful consulting project include clear Terms of Reference, an agreed Program of Work, strong management support and the necessary project support resources including access to information, client management and staff.

Where a clear justification for an application already exists the main objective of a consulting project may be to identify alternative implementation approaches and obtain cost estimates from ICS for a Systems Development Project.

6. SYSTEMS DEVELOPMENT PROJECTS

The following six stages comprise the ICS standard approach to Systems Development.

Stage 1 - Preliminary Systems Study

If ICS have already completed a consulting project, there could be some overlap with the activities involved in the Preliminary Systems Study. In some cases the Consulting and Preliminary Systems Study could be combined.

The primary objectives of Stage 1 are to determine the project scope and environment, broad functional requirements and cost/benefit aspects.

Some of the factors to be considered are:-

* Technical feasibility and alternative systems appoaches
* Whether the system is to be dedicated to a particular function or is to provide for other applications and for systems development facilities.
* Cost/Benefit Analysis
* Time and Cost constraints
* Whether the system is required to cater for future expansion and/or is to link to other areas in the company covered by computer systems.
* Standards for documentation and programming languages.
* Environment and other constraints.
* Current and proposed operating procedures.
* Maintenance/Support/Training.

At the end of this stage, each party should have sufficient understanding of the requirements to be implemented, and the constraints under which they will be provided, for the detailed system specification to be performed.

Stage 2 - External Specification

The external specification defines the operational and physical features of the system from the viewpoint of a user of the system.

A number of inter-related items are considered and specified:

* The detailed functional requirements.
* The hardware configuration - computer and peripherals (bulk storage, printer(s), keyboards(s), VDU'(s), etc.), input/output interfaces, custom-built devices, interfaces to industrial plant/machines, etc.

* The system software - operating system(s), development utility software etc.

* The operating procedures - start-up, shut-down, operator/system communication, report formats, etc.

Initially the detailed functional requirements are obtained and then the appropriate hardware configuration and operating procedures to meet those requirements are specified.

The operating procedures section of the specification effectively becomes the operations manual for the system when used in production.

One further item is the specification of a set of procedures (and possibly some special hardware) to comprehensively test the system. Satisfactory performance of the tests at Industrial Computer Systems premises indicates that the system is ready to be installed at the site, with confidence that disruption to production due to lengthy site commissioning will be minimised.

Acceptance of the external specification signals the "freeze" point of system definition and any subsequent changes are considered as extra to contract with appropriate time/cost implications.

Stage 3 - Internal Specification

The internal specification defines the programs and data structures required to implement the system defined in the external specification.

Three major items are considered:

* Control software - operating system facilities for overall management of the system "driver" software for standard and non-standard devices, communications software, etc.

* Program structure/definition - specification of programs in the system, their function, their interface with the control software, their inter-relationships, and thei interface with the data structures.

* Data structure/definition - specification of data structures and contents, whether fixed data accessed by program or variable data accessed and updated by program.

Stage 4 - Code and Test

During this stage each module defined in the internal specification is coded and tested. Industrial Computer Systems adopts structured design and programming as its default standard, so that as far as possible modules are self-contained and can be comprehensively tested in free-standing mode.

Also during this stage software management "House Keeping" functions are performed - maintaining a "Library" of the modules on various media (disk, diskette, cassette, etc.) and in their various forms (source, object, task), maintaining up-to-date module listings to match the latest version of source, maintaining t   p copies of media, etc.

Stage 5 - System Integrate and Test

During this stage the individual programs previously tested in free-standing mode are linked together and tested as a total system. As far as possible all hardware components in the system are also linked together (by simulation where necessary). In this way the testing is performed in as close to normal operating conditions as possible.

The final activity in this stage is to perform the set of acceptance tests defined earlier. Satisfactory performance of the tests indicates that the system is ready to be delivered to site for installation/commissioning.

Stage 6 - Installation and Commissioning

Activities performed during this stage cover the setting to work of the system in its operational environment.

If required, training of operators is also performed.

The end of this stage is usually demonstrated by satisfactory and uninterrupted system performance for a nominated period. The warranty period begins at this point.

PPC Technical Article

"Australian Process Control System for STD-BUS"

Accurate measurement, monitoring and control of manufacturing and processing equipment can save materials and energy, and reduce labour costs.

There are many small industrial or laboratory process control applications, requiring a mix of direct digital control (DDC) and sequential control, which do not warrant the expense of a large scale process control computer, but which are beyond the capabilities of a programmable logic controller (PLC). One solution to the problem is to use a microcomputer with analog and digital I/O capabilities, and to program the control algorithms in BASIC. Whilst this approach is very flexible, it has many disadvantages. It requires considerable programming skill and experience to write a reliable, error-free system, and it is time-consuming both to write the original system and to change it to meet changing process requirements. Systems programmed in BASIC cannot handle concurrent processes; functions such as DDC, sequencing and operator communication have to be processed serially. This means that while the operator is interacting with the system, the control functions are suspended, with consequent loss of control.

To overcome these deficiencies, and to fill the gap between PLCs and large process control computers, Industrial Computer Systems Pty. Ltd., have developed a Programmable Process Controller (PPC). The PPC, designed and developed in Australia, uses the Z80 microcomputer on Pro-Log STD Bus cards, which are industry-standard components. The PPC software is based upon a real-time multi-tasking executive ("ZEOS"), also developed by ICS. It incorporates a 3-term (PID) DDC algorithm, a sequencing system with interlock capabilities, alarm monitoring and logging, and operator communication through a VDU.

The application is programmed in a high-level process control language (ICSPL) which is purpose designed. The development time is very short, because the user is concerned only with applying the PPC facilities to his particular process problem. To define a control loop, for example, needs only three ICSPL statements: a definition of the analog input, a definition of the analog output, and a definition of the set-point block which relates them.

```
AIBLK TX1,0,105,40,110,0,1023,0
```

defines the analog input block :TX1", using analog input channel 0. The high and low alarm limits are 105 and 40 degrees C respectively, and the transducer range is from 0 to 110 degrees. The 10-bit analog input value ranges from 0 to 1023.

```
AOBLK CV1,0,255,0
```

defines the analog output block "CV1", using analog output channel 0. The 8-bit output value varies from 0 to 255.

```
SPBLK TEMPC1,TX1,CV1,2.0,0.2,100.0,10.0
```

defines the set-point block "TEMPC1", which relates the input TX1 to the output CV1. The DDC deviation alarm limit is 2.0 degrees C, and the PID (proportional, integral, derivative) constants are 0.2, 100.0 and 10.0 respectively.

To initialise the set-point and place the loop on control requires only one sequencing instruction and a parameter block to hold the set-point value, thus:

```
PRMBLK    TEMP1,60.0      - parameter block
SETPT     TEMPC1,TEMP1    - initialise set-point and
                            place it on control.
```

All that is required to complete the control program is to enclose the SETPT instruction in sequence beginning and ending statements.

```
SEQ       LOOP1
SETPT     TEMPC1,TEMP1
ENDSEQ
```

To place the loop on control, the operator simply starts sequence LOOP1, using the built-in operator commands.

Quite complex control schemes can be quickly built up in ICSPL. Up to 16 independent sequences can be programmed. These can communicate with one another via flags and instructions to BEGIN or HALT other sequences. All sequences can run concurrently. In addition, up to 256 sub-sequences can be defined, which can be called by any of the main sequences.

Thirty-two analog inputs and 32 analog outputs can be accomodated, each of which can be used in a control loop. Control loops can be cascaded, simply by defining the output of one set-point block to be a second set-point block.

Special instructions are provided for operating valves and motors equipped with digital inputs to indicate status. These automatically check the operation of the valve or motor. Failures are reported via the VDU to the operator, who has the choice of:

(1) ignoring the failure
(2) proceding from a different point in the sequence
(3) re-trying the operation
(4) aborting the sequence.

Event-based control sequences, known as "RELAYS", can be defined to monitor important process variables, and to take control actions when particular conditions are detected. Interlocks can be defined to prevent control sequences from causing unwanted combinations of valve, motor and control loop states. For example, it might be undesirable to open a cooling water valve while a heating control loop is in operation. One interlock would require that the control loop be off-control when the cooling water valve is opened. A second interlock would require the valve to be closed before the loop could be put on control.

The PPC can be used to control almost any material-processing plant, whether batch or continuous operation is used. It contains the major features of a large-scale process control computer system at a fraction of the cost. Application development time is reduced to a few weeks, and requires no specialist knowledge of computers. Extensive error checking during the development process, and interpretive execution of sequences, ensure bug-free, reliable operation.