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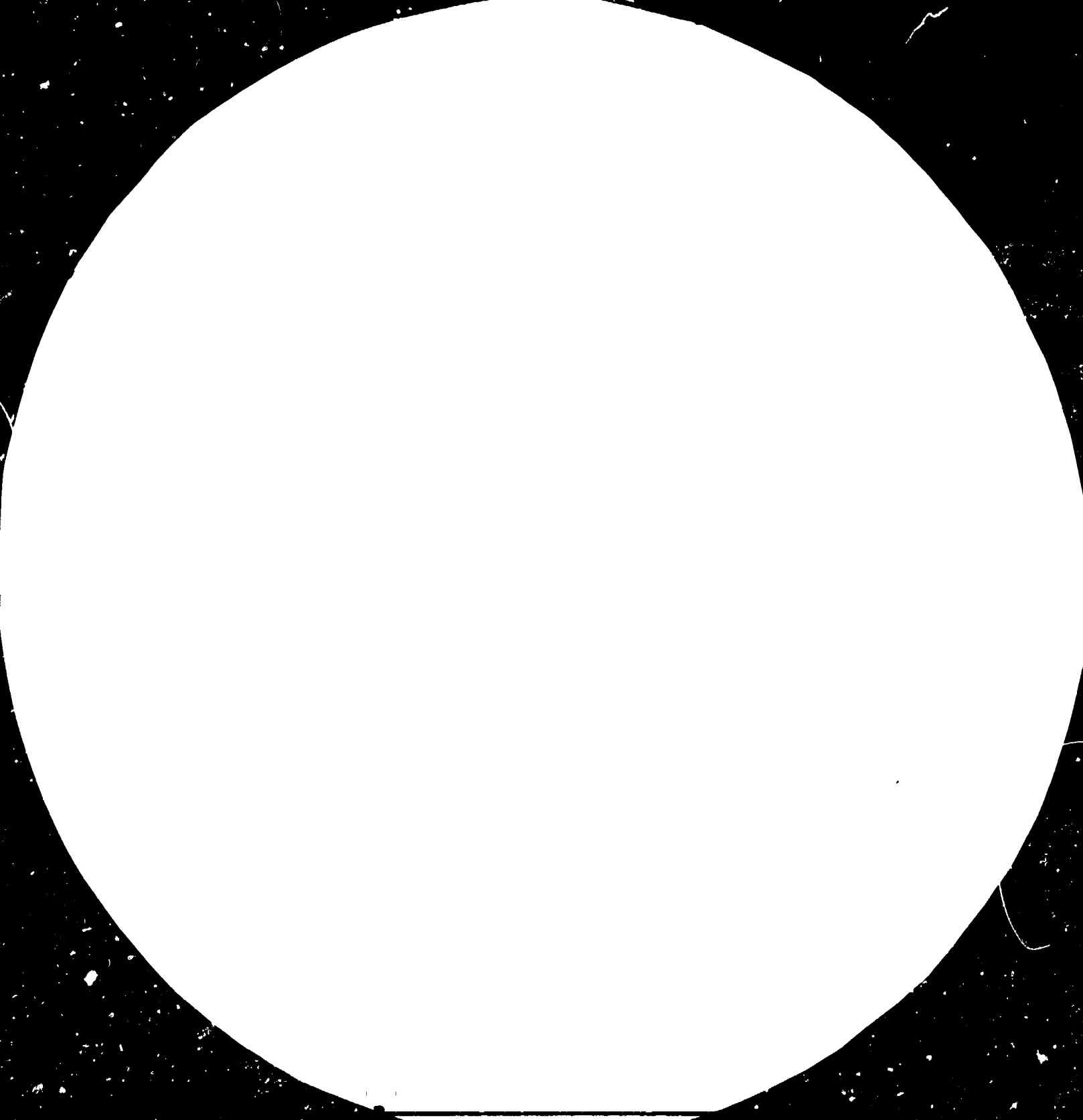
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MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010A

ANSI Z39.48-1968 (PERMANENT)

DP/DRK/79/003

14580

DPR Korea.

ESTABLISHMENT OF A PILOT PLANT

AND TRAINING CENTRE FOR BIPOLAR

DIGITAL INTEGRATED CIRCUITS .

1985

REPORT ON MISSION TO PYONGYANG

22 - 26 February 1985

by

Roy Nuttall

UNIDO Consultant

2322

(Laminated)

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1. INTRODUCTION

The purpose of this interim visit was to assess progress of the IC plant since the previous TAC visit in October/November 1984. In particular to review the situation relative to report issued on that occasion. Also in view of the visits of electrical and exhaust experts a general assessment of all plant services was necessary.

2. REVIEW OF CHECKING LIST COMPILED FROM PREVIOUS TAC REPORT
(25 OCTOBER - 2 NOVEMBER 1984)

A copy of this list is attached and each point is noted in the following comments.

Item

- 1 Part complete
- 2 A quotation has now been received by ETTDC and on due consideration of the machine this should now be purchased. This is manufactured in the UK and is the Cleveland Flat Lapping Machine Model 600. It requires 3 PHASE SUPPLY. It is used extensively in the UK.
- 3 This is to be carried out when all services are complete. This will avoid damaging the surfaces during the installations.

Item

- 4 Part complete but walls will have to be repeatedly assessed for roughness and poor coverage and repainted as necessary. Also some wall cracking was observed and requires attention.
- 5 A manually operated system seems to be functioning which should suffice until an automatic system can be obtained.
- 6 The installation of the water plant is complete but requires certain services. Also the pipeline supplies have now to be installed. Before bringing in the installation engineers (UK) the clean room stations should be in position and all pipe supports and room pipe entries provided. Also it should be remembered that once the D.I. water system is operational it cannot be closed down or left stagnant for periods more than a few days. If left stagnant bacterial growths occur in the pipeline and make extensive pipe cleaning necessary which can have limited success. It is therefore recommended that the D.I. water system is only filled and made operational close to the time of real use.
- 7 This is to be done.
- 8 This is to be considered with the whole gold doped process.

9 The detailed documentation for each process flow step should now be detailed as much as possible to assure that all facilities are available.

Suggested detail would include

- (a) Slice transportation and carriers between stations.
- (b) Slice cleaning - container, jigs, amount of reagent, hot/cold, carried out in which room and at which station.
- (c) Process times including all steps and which equipment/furnace is to be used.
- (d) Slice measurement - method, where carried out, how many equipments.
- (e) Detail of stocks of consumable items and chemicals.
- (f) A general program showing the movement of slices within the complex during processing with an indication of the time scale.

THIS IS NOW CONSIDERED NECESSARY AND WILL HELP ALL PARTIES. ETDC
WITH ASSISTANCE FROM MR. J. GYIMESI SHOULD ACTION.

- 10 Being carried out.
- 11 Being carried out.
- 12 Complete cleaning up necessary.
- 13 Part done - rubbing down and more paint required.
- 14 Lights in place.
- 15 Door sealing part done but require adjustment.
- 16 Not done as yet but could be left until later as could get damaged in meantime with excessive "traffic".
- 17 In process of being carried out.

- 18 This has not been done and could be left until later to avoid undue wear or damage.
- 19 Part done.
- 20 This now carried out.
- 21 Doors fitted but some require adjustment. Some are fire doors and require labelling as such. Air showers in position but not fitted.
- 22 Provided in position but not fitted.
- 23 Not done.
- 24 This is being pursued by UNIDO who are arranging visit by suppliers suggested in Mr. P. O'CARROLL REPORT (27th November - 11th December 1984). These will be assessed and orders placed in due course.
- 25 The ceiling covering followed by painting is generally satisfactory however it will need reappraisal to note any deterioration which may occur. There are areas inside light fittings which require patching and painting.
- 26 Ceiling glands appear satisfactory. They allow for 4 pipe entries per gland and will take pipe entries of $\frac{1}{2}$ " DIA. to $\frac{3}{4}$ " DIA. These would suit pipes involved. The positions of glands may not be ideal in view of some equipment changes occurring they can still be used.
- 27 Complete but for cleaning up.
- 28,29,30,31 These are covered in following section 3.1 Services.
- 32 See item 3 this section.
- 33 Cannot be done seriously until services established.

- 34 This is to be done by INST on receipt of drawings currently being prepared by ETTDC, TAC and PROJECT MANAGER.
- 35 This is discussed Section 3.2 Services.
- 36 This is discussed in the report of Mr. L. DUNNE (27th November - 11 December 1984) and gives his recommendations together with a supplier of a suitable system. This should now be actioned by the Institute and UNIDO should help wherever possible.
- 37 The floor covering to the process areas is now well under way. However the butt joints are not always tight, some cockling has occurred and the covering has not been allowed to roll up the wall at floor/wall angles. It was recommended previously that the floor covering should pass over floor and pass up wall 6" without a break. Unfortunately so far this has been broken and joints made. In all future work this is to be avoided.

Obviously the Institute are learning techniques from the work so far so that one assumes the floor should improve. However the following comments should help.

- (a) Avoid trapping air under covering when laying which causes cockling. Also prolonged contact of covering with adhesive.
- (b) Make sure edges are square and good fit before applying adhesive. Remove all dust and make sure butt joints are tight.
- (c) Allow floor covering to run up wall on all four sides. Two opposite sides by length and other two sides by edge trimming to size to allow 6" up the wall. All corners can be overlapped.

The floors which have already been covered should be left to assess any deterioration. The position of equipment may cover cockled areas and it may be necessary to seal further with plastic tape later. Removal of floor covering at this stage would be a major operation.

- 38 Laminar flow boxes are being positioned where possible. The modification to boxes re-position of electric sockets etc. is still to be done.
- 39 Water service reviewed Section 3.5.
- 40 Power supply reviewed Section 3.1.
- 41 Manual system now being tested.
- 42 H₂ supply discussed Section #.7.
- 43 NO INFORMATION.
- 44 To be done at appropriate time.
- 45 Has now been carried out.
- 46 This has been arranged by ETTDC for all chemical stations. Water washing stations is not to be recirculatory.
- 47 To be carried out in due course when rooms are nearer completion. No measurements reported so far.
- 48 Again to be assessed when rooms and equipment nearer completion.
- 49 This has still to be done. The Institute suggest separate switches but these could produce dangerous situations for personnel. The system should be automatic such that when power fails the emergency lighting system comes on immediately.
- 50 This is being done.

- 51 Spares for air conditioning plant have been provided by
ETTDC according to manufacturers recommendation.
- 52 To be considered in due course.
- 53 Not done.
- 54 This is complete.
- 55 Not done.
- 56 To be carried out.
- 57 To be done.
- 58 Not ordered as yet.
- 59 This can be done later in year and quotation being obtained.
The present system can be used in the meantime.
- 60 To be provided.
- 61 To be provided.
- 62 Still to be carried out.
- 63 Chemical storage facility available. Survey report available.
- 64 See Section 3.2.
- 65 Not available as yet.
- 66 Tables are substantial and of all steel construction.
They are in themselves relatively dust free but paint
is not sufficient as soft and will match. Working surfaces
should be covered in FORMICA or similar material.
Design of cabinet etc. attached and as all steel construction
should be suitable. However gloss paint finish required.
- 67 These rooms to be completed but not used for present.
- 68 This is being pursued.
- 69 Masks are now being obtained by ETTDC.
- 70 These were agreed at previous meeting.

- 71 This will be carried out in due course.
- 72 This would be part of proposed STAGE 2 section of the present project.
- 73 To be carried following plant services review.
- 74 Not available as yet.
- 75 This is bererally being provided.
- 76 Spin-on dopant shelf life is too short - purchase nearer the time of usage.
- 77 Various methods of parameter measurement are suggested but equipment embargo will limit technique. However method offered is generally used for this scale of operation.
- 78 To be carried out in due course.
- 79 This is still to be done and is dependent on mask availability. Being pursued.
- 80 This has been done.
- 81 Requires further discussion.
- 82 This machine is now to be ordered (ITEM 2).
- 83 Machine now ordered, the technique + methods are included with machine. The position of lapping process in process flow will be determined when flow chart detailed (ITEM 9). Amount of material to be removed will also be determined. Machine processes 9 slices per batch in blocks of 3.
- 84 This has been done but requires air extraction which is being fitted in the very near future. .
- 85 This has been done.
- 86 See Section 3.7.
- 87 This is being pursued.

- 88 This information outstanding.
- 89 Not known.
- 90 Now available.
- 91 Not complete as yet.
- 92 Not complete as yet.
- 94 Not available as yet.
- 95 Report Mr. L. DUNNE (27 Nov - 11 Dec 84) See Section 3.1
- 96 Reports Mr. P. O'CARROLL + K.G. KUNNIFF June 84.
Discussed previous TAC REPORT 25 Oct - 2 Nov 1984.
- 97 Report Mr. P. O'CARROLL (27 Nov - 11 Dec 84).
- 98 This Report - R. NUTTALL (22 - 26 February 1985).

3. CONSIDERATION OF PROGRESS AND PROBLEMS ASSOCIATED
WITH SERVICES TO PLANT

It is now becoming more apparent that the main delays to the project will be associated with a lack of adequate services. These are reviewed as follows:

3.1 Electrical Power Supply

This has recently been reviewed by UNIDO expert Mr. L. DUNNE in his report 27th November - 11th December 1984. The basic problem would be the voltage variation and he offers suggestions for correcting same. The variation that many equipments used in plant would be $\pm 5\%$ maximum. The results reported are $+ 3\% - 24\%$ which could on load fall to $- 32\%$.

This would not be acceptable as much of the equipment would be useless. Mr. DUNNE does offer methods of correcting this problem in his report and those should be checked followed by procurement of the necessary components. This involves the Institute but UNIDO should check that any purchases are correct and help in perhaps accelerating delivery etc. In addition to the variation, the general standard of power fittings, switches, junction boxes, etc. were said to be inferior. This was pointed out in the last TAC report and a general purchase of adequately rated and accepted electrical installation components should be carried out.

General examination of power fittings and outlets suggests some were up between single and 3-phase outlets and a notable absence of earth pins. The whole electrical network should be fitted under expert supervision.

Mr. DUNNE also makes suggestions for a fire alarm system and a dangerous gas alarm system. These should also be examined with intent to instal.

The Institute would seem responsible for all above actions but they may require confirmation of variations. This should therefore be confirmed by chart recorder so that a realistic trace can be obtained over a suitable period. Having established this and assuming variation of the order reported action should be taken in obtaining necessary components. UNIDO should help as much as possible ensuring that the correct components are obtained.

3.2 Extraction

Again this involves the recent visit of a UNIDO expert Mr. P. O'Carroll who has provided a complete extract design for the complex together with supplies of the necessary components. This should be actioned as soon as possible and UNIDO make the necessary purchases. UNIDO should help in possibly accelerating delivery of the components.

It is understood that Mr. P. O'Carroll or other expert will supervise the installation of the system while the Institute provide the labour involved. It is important that ETTDC are kept involved as they are responsible for the air conditioning which is directly related to the Extraction. It is also understood that no fume scrubbers are involved in the system and with the relative small size of the plant it would seem unnecessary at this stage.

Again the urgency of this plant construction is emphasized.

3.3 Air Conditioning

The air conditioning was considered in some detail in the previous report with the comments of Mr. P. O'Carroll and Mr. K.G. Cunniff in their reports. Again it is noted that there are differences of opinion between the reports and ETTDC but this will only show when system fully tested. Preliminary tests are underway and their findings will be

reported by ETTDC. If inadequate in any way ETTDC will make necessary changes. It should be noted that the extraction system will greatly affect these results so that complete tests can only be made when both systems operational.

3.4 Compressed Air

This service has already been piped from the compressor to the building in stst welded pipe. It is however suggested that the remaining pipe network is piped in 1/2" copper tubing with brass compression fittings. This would make installation easier and avoid using oxy/acetylene welding equipment in the part completed clean rooms where some unnecessary damage may be inflicted on wall or floor. Copper tube + fittings are readily available. A few pressure guages placed in the line for reference would be useful.

3.5 Water Supply

The water supply consists of 3 forms:

- (a) deionized water
- (b) raw water
- (c) recirculated raw water.

The deionized water plant is ready for completion and the pipe system installing. However as already pointed out after commissioning if the system left stagnant then heavy bacterial growths can occur leaving a major cleaning operation to be done. The installation should therefore

be left to time nearer the usage time.

The raw water is used for showers and some cooling and a drawing of pipe circuit is being compiled at present by ETTDC in cooperation with TAC and Mr. Gyimesi. This drawing will show all water supplies, drains and gas pipe network.

The recirculated raw water is used exclusively for equipment cooling and the network is shown on drawing.

This water should be recirculated through a suitable heat exchanger/fountain/tank and not returned to underground spring. If faults occur on equipments this water could become seriously contaminated and returning to spring could be dangerous. Also the pick up of silt in using spring for heat dissipation could provide problems of blocked pipes on equipments.

It is also essential at this stage that the total water requirements are assessed and to make sure the supply adequately covers this figure. Also if for any reason the water supply has changed in nature from original supplies, new samples should be delivered to the D.I. plant manufacturer for analysis. All water supplies originate in the basement as agreed.

3.6 Drains + Effluent Treatment

These are also situated in basement and pass through holes in clean room floors. The plant drawing being produced

shows their position. All drains pass into an effluent treatment plant which is undergoing tests. The current system is operated manually and will be subsequently replaced by an automatic system.

3.7

Gas Plant

The gas plant involves the generation of N_2 , O_2 and H_2 . All the plant has been installed and requires services. These are not all available and hence the units cannot be tested or in due course made operational. The pipelines from the gas plant to the main building have been fitted and require cleaning and testing. However the pipes are stainless steel but have been welded using oxy/acetylene torch and the welds are heavily oxidised, hence the weld integrity is questionable. It is standard procedure to weld stst using argon arc techniques which avoids oxidation. A method of assessing the weld will have to be found and checked during testing. The gas line pressures are however low relative to the size of pipe 7 BAR. The hydrogen line would of course be the most dangerous as any H_2 leaks which might develop could cause explosion. It may be wise to replace this line with a continuous run of 3/8" stst which is to be available.

Also it was reported previously that the H_2 capacity was insufficient. We now have confirmed that the present plant can be used and at a convenient later date the gas generator and other items be replaced to give increased capacity. ETTDC are awaiting details and quotations of the new plant.

3.8 Special Gases

These still require the storage cabinets producing and also the H.P. nitrogen cylinder, HP N₂ regulator for the purge system are not available. All the above require action.

3.9 Workshop Facilities

It would seem that the provision of workshop facilities has not been discussed for some time. The basic needs to support plant operation were listed in a previous TAC report and requested some sophisticated machinery. However during the installation program where outside contractors are involved the provision of a simple workshop, with bench vices, drills and general basic tools would greatly help visiting engineers.

As well as workshop facilities in due course a quartz/glass working lathe and torch capability will be required to repair and fabricate furnace tubes etc.

3.10 Use of Equipment

It is now understood that some of the equipment can now be tested and operated to some extent. This is particularly so in the assembly area but lack of services is creating problems and delays.

However already some bonding has been carried out by Institute engineers and it is suggested that where equipment can be operated the Institute engineers should familiarize themselves with the equipment and appreciate the day to day workings of such machines.

IT IS IMPORTANT THAT THIS IS NOT CARRIED OUT WITHOUT PERMISSION OF ETTDC.

4. POINTS RAISED AT FINAL MEETING DURING VISIT

During discussions the following points were raised by the Institute and require action by ETTDC.

- (a) The position of the air diffuser relative to certain work benches raises some concern. It seems that gross interference in the air flow paths can occur resulting in poor clean air distribution. This should be checked as soon as possible as if needs correction either resiting of bench or diffuser may be necessary.
- (b) ETTDC should supply all information on equipment purchased for gold dope diffusion process.
- (c) Also it is important that when new metal false ceilings are being designed into Yellow Room etc. then ETTDC should become sufficiently involved to assure that diffuser changes are acceptable to produce required clean room conditions.

CONCLUSIONS

Although progress to the building has been made it is now apparent that the current delays are associated with the services. It is therefore essential that the section on services is appreciated and that all action possible taken by all the parties involved.

It is obvious that although clean room conditions are important, they will in general only reflect in the yield of devices. The absence of adequate services simply renders the plant inoperative such that no devices can be produced.

R. N. Attall

DP/DRK/79/003 - Integrated Circuits

Checking list of remaining TAC and other recommendations
to complete the project

Date of issue:

<u>Item</u>	<u>Description</u>	<u>Responsibility</u>
1	Sleeve service entries into process rooms with PVC	INST
2	Provide lapping machine for gold doping	ETTDC
3	Paint floor on the SF	INST
4	Apply additional paint /walls and ceiling on the 2nd floor/	INST
5	Complete effluent treatment system	INST
6	Install DI water plant	ETTDC
7	Replace HNO ₃ boil with phase oxidation	ETTDC
8	Backlap after process step 40 to remove gold	ETTDC
9	Provide detailed documentation for each process flow step	ETTDC

<u>Item</u>	<u>Description</u>	<u>Responsibility</u>
10	Provide lapping machine /same as item 2/	ETTDC
11	Provide additional manual bonder	ETTDC
12	Install aluminium door frames and window in the changing room	INST
13	Paint walls and ceiling in the changing room	INST
14	Install ceiling lights in the changing room	INST
15	Seal corridor doors	INST
16	Install floor covering in the changing room	INST
17	Paint walls on the corridor	INST
18	Install floor covering on the corridor	INST
19	Clean window frames on the corridor	INST
20	Install ceiling lights on the corridor	INST

<u>Item</u>	<u>Description</u>	<u>Responsibility</u>
21	Fit aluminium doors to clean rooms and fit air showers	INST
22	Provide one air shower to each room	INST
23	Adapt end doors to fire doors	INST
24	Install metal ceiling	INST
25	Carefully apply plastic sheeting	INST
26	Supply ceiling gland drawings	INST
27	Complete aluminium window frames	INST
28	Use standard and safe electrical hardware	INST
29	Affix switch boxes to the wall properly	INST
30	Clean inside of switch boxes	INST

<u>Item</u>	<u>Description</u>	<u>Responsibility</u>
31	Use "top hat" installation of boxes	INST
32	Clean and paint floor on 1 SF	INST
33	Seal service entries	INST
34	Install pipework support trays	INST
35	Supply extraction system drawings	INST
36	Install fire doors and fire alarm system	INST
37	Install floor covering	INST
38	Position and install laminar flow boxes	INST/ETTDC
39	Install DI water and raw water pipework	INST
40	Supply stabilized voltage	INST

Item	Description	Responsibility
41	Supply effluent system drawing	INST
42	Provide auxiliary H ₂ supply	ETTDC
43	Obtain anti-vibration mounting equipment	INST
44	Check air conditioning diffusers during test phase	ETTDC
45	Seal windows with silicone sealer	INST
46	Provide recirculation for chemical benches	ETTDC
47	Test temperatures during test phase	ETTDC
48.	Provide required air distribution /no dead spots/	ETTDC
49	Provide automatic emergency lighting	ETTDC
50	Provide documentation for items 1-7 on pp. 19 and 20 of O'Carroll's report	ETTDC

<u>Item</u>	<u>Description</u>	<u>Responsibility</u>
51	Provide spares for airconditioning plant /items 1-8 on p. 20 of O'Carroll's report/	ETTDC
52	Redesign diffusers as shown in TAC report if necessary	ETTDC
53	Revise top floor ceiling air exits	INST
54	Install ceiling insets to accomodate evaporators	ETTDC
55	Provide properly designed gas storage cabinets	INST
56	Clean laminar flow boxes and relocate their electrics	ETTDC
57	Refit air showers	INST
58	Provide diffusion cylinder regulators	ETTDC
59	Increase H ₂ plant supply	ETTDC
60	Provide 3 torch oxidation units	ETTDC

<u>Item</u>	<u>Description</u>	<u>Responsibility</u>
61	Provide 4 diffusion furnace monitoring thermocouples	ETTDC
62	Provide ventillation in first floor changing room	INST
63	Provide location for chemical storage	INST
64	Provide and check exhaust system design	INST
65	Provide refrigerator	INST
66	Provide dust inhibiting funiture for clean rooms	INST
67	Complete mask making and crystal pulling rooms as planned	INST
68	Continue to locate sources for mask making and crystal pulling equipment	UNIDO
69	Obtain masks and dice	ETTDC/UNIDO
70	Provide plan performance test specifications	ETTDC

<u>Item</u>	<u>Description</u>	<u>Responsibility</u>
71	Train institute personnel as equipment is installed	ETTDC
72	Provide training abroad for DPRK engineers	UNIDO
73	Update the project flow chart /from now to completion/	ETTDC
74	Provide vibration measurement equipment	INST
75	Expedite remaining project equipment delivery and report status every 2 weeks	ETTDC
76	Provide spin-on dopant for process flow item 11	ETTDC
77	Provide advice to ETTDC on epitaxy process /flow chart item 14/	R.NUTTAL
78	Use BS5295 when testing air conditioning	ETTDC
79	Identify 2 IC types to be used in plant performance test	ETTDC
80	Order 50,000 D110 type devices from Elektrotechnik, GDR	UNIDO

<u>Item</u>	<u>Description</u>	<u>Responsibility</u>
81	Expand proposal for skill development training	ETTDC
82	Advice R.Nuttal by telephone of gold lapping specifications	ETTDC
83	Provide advice to ETTDC on gold lapping	R.Nuttal
84	Isolate the moulding press	INST
85	Reorder vacuum pumps to 60 Hz specs	UNIDO
86	Provide information on enlarging H ₂ plant	R.NUTTAL
87	Resolve problem of inserting spare quartz tube into ceramic sleeve in diffusion furnace	ETTDC
88	Supply written description /with parameters/ of test masks	ETTDC
89	Certify DPRK personnel in English Language Proficiency	UNEP
90	Provide 300,000 lead frames	ETTDC

<u>Item</u>	<u>Description</u>	<u>Responsibility</u>
91	Provide test specs for completed wafers	ETIDC
92	Provide test specs for assembled devices	ETTDC
93	Provide marking ink for completed wafers	ETTDC
94	Publish final list of supplies, tools, spares to be supplied by ETIDC, INSTITUTE, UNIDO	J.GYIMESI
95	Provide expert in power substation	UNIDO
96	Provide expert in air conditioning	UNIDO
97	Provide expert in exhaust system design and test	UNIDO
98	Arrange for monitoring visits in December 1984 and January 1985 by individual TAC members	UNDP

