Extension Project for the Existing Tseung Kwan O 400kV Substation

1 PROJECT DESCRIPTION

This project calls for the reinforcement of the 400kV network at Tseung Kwan O 400kV Substation to enhance the supply security to Tseung Kwan O and East Kowloon areas by installing additional 400kV shunt and series reactors in Tseung Kwan O Substation (S/S).

2 NATURE OF THE PROJECT, AND THE PROPOSED ADDITION, MODIFICATION OR ALTERNATION

To cater for the load growth in Tseung Kwan O and East Kowloon areas, it is necessary to enhance the reliability and security of network supply arrangement at Tseung Kwan O 400kV S/S. Based on the forecast load growth, additional 400kV shunt and series reactors are required to be installed in Tseung Kwan O 400kV S/S at Year 2003/4. As no additional space was reserved inside the existing substation buildings at the original design, a single storey civil structure of reactor bays with roof is planned to be built at the back of the substation to house the additional series reactors and shunt reactors. The layout plan is attached in Appendix 1. The additional reactors are required for the purpose of reactive load compensation and 400kV network security enhancement.

The proposed extension area is not located within the Country Park, conservation area and site of special scientific interest. Moreover, the additional land required for the extension project is zoned 'GIC' on the Tseung Kwan O Outline Zoning Plan No. S/TKO/7

3 NAME OF PROJECT PROPONENT

CLP Power Hong Kong Limited

4 LOCATION OF PROJECT

Tseung Kwan O 400kV Electricity Substation. Wing Lai Road, Tseung Kwan O.

5 NAME AND TELEPHONE NUMBER OF CONTACT PERSON(S)

Projects Manager - East
Projects Engineer
Projects Manger - Civil
Environmental Officer

6 DETAILS OF PROPOSED ADDITION, MODIFICATION AND ALTERATION

The following major equipment is to be installed in the proposed extension area of Tseung Kwan O 400kV S/S:

1 One 400kV series reactor
2 Two 400kV shunt reactors
3 One 132kV shunt reactor (for future)

To house the additional reactors, a concrete structure for reactor bays with roof-top will be erected at the bottom side of the existing hill slope at the back of substation as shown in the Appendix 1. Other electrical equipment including the switchgears will be housed inside the existing building. Prolonged lease modification process is required to acquire the additional piece of land for this civil structure, which falls outside the existing substation lot boundary.

7 TIME TABLE / SCHEDULE

The milestone dates are proposed below:

Environmental Permit obtained from EPD:	Early 2000
Lease modification completed and premium paid:	Mid 2001/2
Superstructure completed:	Mid 2003
Plant installation completed and all equipment commissioned:	Mid 2004

8 POSSIBLE IMPACT ON THE ENVIRONMENT

The possible environmental impacts that are identified with this substation extension project, with the consideration of existing environmental setting, TM of EIAO and previous EIA report, include: -

- Air Emission
- Effluent Discharge
- Noise Emission
- Electromagnetic Field
- Waste Management
- Visual and Landscape

8.1 Air Emission

8.1.1 Operational Phase

No air pollutants emission are discharged from the operation of reactors.

8.1.2 Construction Phase

Fugitive dust is considered the main air pollutant emitted from the construction phase. The following activities are considered to be the potential source of fugitive dust emissions: -

- Grading and levelling of ground
- Removal of spoil
- Site stripping
- Earthworks
- Site and slope excavations
- Concreting operations
- Site reinstatement and road construction

8.13 Proposed Mitigating Measures

Based on the small scale and period of construction activities within the limited site area, the fugitive dust emission from the construction site is limited. The emission will be further reduced by adapting appropriate site housekeeping practice and mitigating measures throughout the construction period.

- Keeping the unpaved roads and site wet by regularly watering in order to suppress the dust emission from the site.
- Where breaking of concrete road is required, watering shall be implemented to control dust emission.

- Dropping heights for excavated materials should be controlled to practical height to minimise the fugitive dust from unloading.
- All dusty materials should be sprayed with water immediately prior to any loading, unloading or transfer operation.
- All stockpiles of aggregate or spoil should be covered by impervious sheeting or placed in an area sheltered on the top and at three sides.
- Wheel washing facilities will be provided on site for all vehicle before leaving the site.

8.2 Effluent Discharge

8.2.1 Operational Phase

No effluent will be discharged from the operation of reactors.

8.2.2 Construction Phase

The potential sources of effluent discharge mainly come from the surface runoff during the construction period. No sewage effluent will be discharged from the site as chemical toilet and exiting toilet facilities within the substation block will be provided. The construction site will be managed in according with the EPD's *Practice Note for Professional Persons – Construction site Drainage (ProPECC PN1/94).* Thus, the water quality impact during the construction phase is considered negligible.

8.3 Noise Emission

8.3.1 Construction Phase

Table 8.3.1 summarises the Powered Mechanical Equipment (PME) that would be employed during the construction phase. The predicted noise level at the nearest NSRs due to the various work process is calculated in accordance with the relevant Technical Memorandum of Noise Control Ordinance. Only one of the five work processes that involving the use of PME will be taken at any one instant as far as practicable. The noise standard for daytime construction activities is 75 dB(A) as stipulated in the Technical Memorandum on Environmental Impact Assessment Process. The locations of nearest noise sensitive receiver are identified in the location map in Appendix 2. The result of noise assessment at the nearest noise sensitive receivers (NSR) is summarised in the Table 8.3.2. No exceedance of daytime noise standard is observed.

Table 8.3.1 Sound Power Level of major Powered Mechanical Equipment for the various work processes during the construction phase

Powered Mechanical Equipment (PME)	Sound Power Level, dB (A)	Quantity	Work Process that involving the use of PME				
			Pile driving	Excavation	Levelling	Concreting	Boulder
Pneumatic Breaker, mass >10kg and <20kg (CNP 024)	108	2		√	√		√
Air Compressor, air flow <10m^3 /min (CNP 001)	100	1		√	√		
Concrete Poker ((CNP 170)	113	2				√	
Excavator/Backhoe (CNP 081)	112	2		√			√
Hydraulic hammer (single acting) driving steel pile	126	1	√				
Concrete pump truck (CNP 047)	109	1				√	
Concrete lorry mixer (CNP 044)	109	2				√	
Total SWL for particular process			126	115	112	118	116

Table 8.3.2 Predicted Maximum Noise Level at the identified NSRs during construction phase

NSR	Location	Shortest horizontal distance from the NSR, m	Predicated maximum noise level at the various construction work process that involving the use of PME				
			Pile driving	Excavation	Levelling	Concreting	Boulder
1	Spanish style residential block	90	75	68)	65	71	69
2	TKO Temporary House	120	72	65	62	68	66
3	TKO Village	200	67	61	58	64	62

Note: the predicted maximum noise level do not consider any noise mitigation and correction to the screening effect by the slope and existing substation blocks

8.3.2 Operational Phase

Two 400kV Shunt Reactors and one 400kV Series Reactor is to be housed into the reactor bays in this project. A 132kV shunt reactor will also be installed in future (depend on the condition of future loading). The opening of reactor bays, which facing the substation block A, will be installed with acoustic roller shutter to form an enclosed transformer bays. The acoustic roller shutter shall have transmission loss of, at least, 10 dB(A) at 100 and 200 Hz.

The daytime and nighttime noise standards at the identified noise sensitive receivers are 55 and 45dB(A) respectively. The result of noise assessment for the reactors operation is summarised in Table 8.3.4 and 8.3.5. Full compliance of noise criteria as stipulated in the Technical Memorandum of EIAO is observed.

Table 8.3.3 Sound Pressure Level, dB(A), of the Reactors

Reactor	Quantity	Ref. Distance (m)	Sound Pressure Level, dB(A)
400kV 1000MVA Series Reactor	1	6.3	80.0 dB (A)
400kV 100MVAr Shunt Reactor	2	6.3	74.0 dB (A)
132kV Shunt Reactor for future	1	6.3	68.0 dB(A)
Combined Noise Level		6.3	82.0 dB(A)

Table 8.3.4 Predicted Maximum Noise Level at the NSRs during Operational Phase (without the consideration of any noise mitigation)

NSR	Location	Shortest horizontal distance from the site to NSR	Maximum Noise Level dB(A)	Noise Standard ,dB(A)
1	Spanish style residential block uphill	90	59	45
2	TKO Temporary House	120	56	45
3	TKO Village	200	52	45

Table 8.3.5 Corrected noise level (CNL) after considering the mitigating measures and correction factors

NSR	**1**	**2**	**3**
Predicted SPL, dB(A)	59	56	52
Facade Correction, dB(A)	+3	+3	+3
Tonal Correction at 100 & 200 Hz, dB(A)	+3	+3	+3
Attenuation by the totally enclosed reactor bay structure, dB(A)	-20	-10	-10
Screening by hill slope, dB(A)	-5	0	0
Screening by Substation Blocks, dB(A)	0	-15	-15
Corrected Noise Level, dB(A)	40	37	33

8.3.3 Mitigating Measures

Although the predicted maximum noise level at the nearest NSR during the construction phase comply with the daytime noise limit of 75 dB(A) as stipulated in the Technical Memorandum of EIAO, further appropriate mitigating measures such as using low noise PME, adopting good housekeeping practice and installing appropriate silencer for some PME would be considered whenever practicable. Depending on the final agreement with civil contractor, other alternative methods might be considered to replace the piling work if practicable. Moreover, no construction work is to be taken from 0700pm to 0700am on Monday to Saturday and all day on Sunday and Public Holiday.

Although the noise impact to the nearest NSR is negligible during the operational phase, opportunity to procure reactors with relatively lower sound pressure level will be seek as far as practicable.

8.4 Waste Management

8.41 Operational Phase

Only negligible amount of solid waste will be generated during the routine maintenance work for the reactors. The situation is the same as the existing transformer and reactors in the Tseung Kwan O 400kV substation.

8.4.2 Construction Phase

During the construction activities, the following wastes are likely to be generated: -

- General Construction Waste – Wastes generated during the construction works include general refuse, low grade vegetation from the slope cutting, wood from formwork, materials and equipment wrappings etc.
- Excavation Materials – Theses materials are expected to be inert such as soil and demolition waste (asphalt and concrete).
- General Refuse – It may include paper, food and packaging waste. The improper storage of general refuse has the potential to give rise to a variety of adverse environmental impacts. These include odour and windblown litter.
- Chemical Waste – It includes the oily rags, used hydraulic and lubricating oil and some residual paints. It is expected that only insignificant amount of chemical waste will be generated from this construction work activity.

8.4.3 Mitigating Measures

Based on the type and scale of construction work, site clearance waste and excavation materials account for the significant proportion of construction waste from the site activity. The following mitigating measures will be adopted during the work activities.

Excavated Materials	Stockpiled in designated areas away from drainage areas. The material will be removed off site as soon as they are not required. Stockpiles shall be covered at all time to avoid duste generation and wash off during windy and rainy conditions.
General Construction Waste	Store on designated site area to remove material which is suitable for recycling, reuse or use in public dumps. The remainder will be disposed of at the designated landfill site as soon as practicable.
General Refuse	Temporary storage areas for general refuse shall be provided which are enclosed to avoid the attraction of pest. General refuse will be disposed of to the landfill as soon as practicable.
Chemical Waste	The storage, handling and disposal of chemical waste will be managed in accordance with the Code of Practice on the Packaging, Labelling and Storage of Chemical Waste published by the EPD and the Waste Disposal (Chemical Waste) (General) Regulation.

8.5 Electro-magnetic Field (EMF) Effects

When electricity is used, electric field is produced by the voltage in a conductor and magnetic field is produced by the current or flow of electricity in a conductor. The electric and magnetic field strengths decreased rapidly with distance. As the new reactors are enclosed within the respective metal cladding and are earthed, the EMF emitted from the reactors is only minimal. With the consideration of shielding/screening effect of enclosed reactor bays and significant distance attenuation effect, the electric and magnetic field strength are anticipated to be as low as the existing background level and well below the ICNIRP limits even at the substation boundary. Thus, the effect of EMF from the addition reactors to the nearby resident is considered negligible. The recent EMF measurement result at Shatin 400kV Substation, which is quite similar to the exiting Tseung Kwan O 400kV Substation, is attached in Appendix 3 for reference.

8.6 Visual and Landscaping Impact

Four reactor bays of 8 meter wide and 10.5 metre high (two 17 meter long, one 27 meter long and one 16 meter long{for future}) are proposed to be built at the back of the Substation by cutting the existing slope area. The dimensions of existing substation block A is 30m H X 74m L and B is 19.5m H X 50m L (Refer to the previous EIA report at Appendix 5). The left and right access road within the substation will also be widen from 3 m to 8 m and 7m respectively by cutting the existing slope. Relevant proposed layout plans are shown on the attached drawing in Appendix 1.

Based on the location and dimension of proposed reactor bays, the visual impact to the nearest sensitive receiver is considered minimal as the area is shielded by the existing substation blocks and hill slopes from the sign of nearest receivers (the location of sensitive receivers refer to the previous EIA report). The actual views of Tseung Kwan O 400kV substation and its access roads are shown in Appendix 4. According to the result of previous EIA report, the dimension of new reactor bays and area of new access roads, the cumulative visual impact of Tseung Kwan O 400 kV Substation to the nearby resident due to this substation extension project is considered negligible to minimal.

This extension project will involve the slope cutting on the back of the substation, east and west of the substation boundary. Approximately 86m X 11m area will be cleared. Most of the vegetation within the project area were planted by CLP Power Hong Kong Limited after the establishment of Tseung Kwan O 400kV S/S as recommended in the previous EIA report. The affected area is marked in the tree survey diagram in the Appendix 5. Plants need to be removed or affected by this extension project are identified as low ecological value and very common in Hong Kong.

8.6.1 Mitigating Measures

- The cleared slope will be reinforced and hydroseeded. Appropriate number of vegetation (same or similar species) will also be replanted after the project work has been completed as far as practicable.
- Responsible civil contractor will close monitor the slope cutting work to avoid unnecessary disturbance of plant species outside the cleared boundary.
- The colour of new extension will be in consistence with the existing building block.

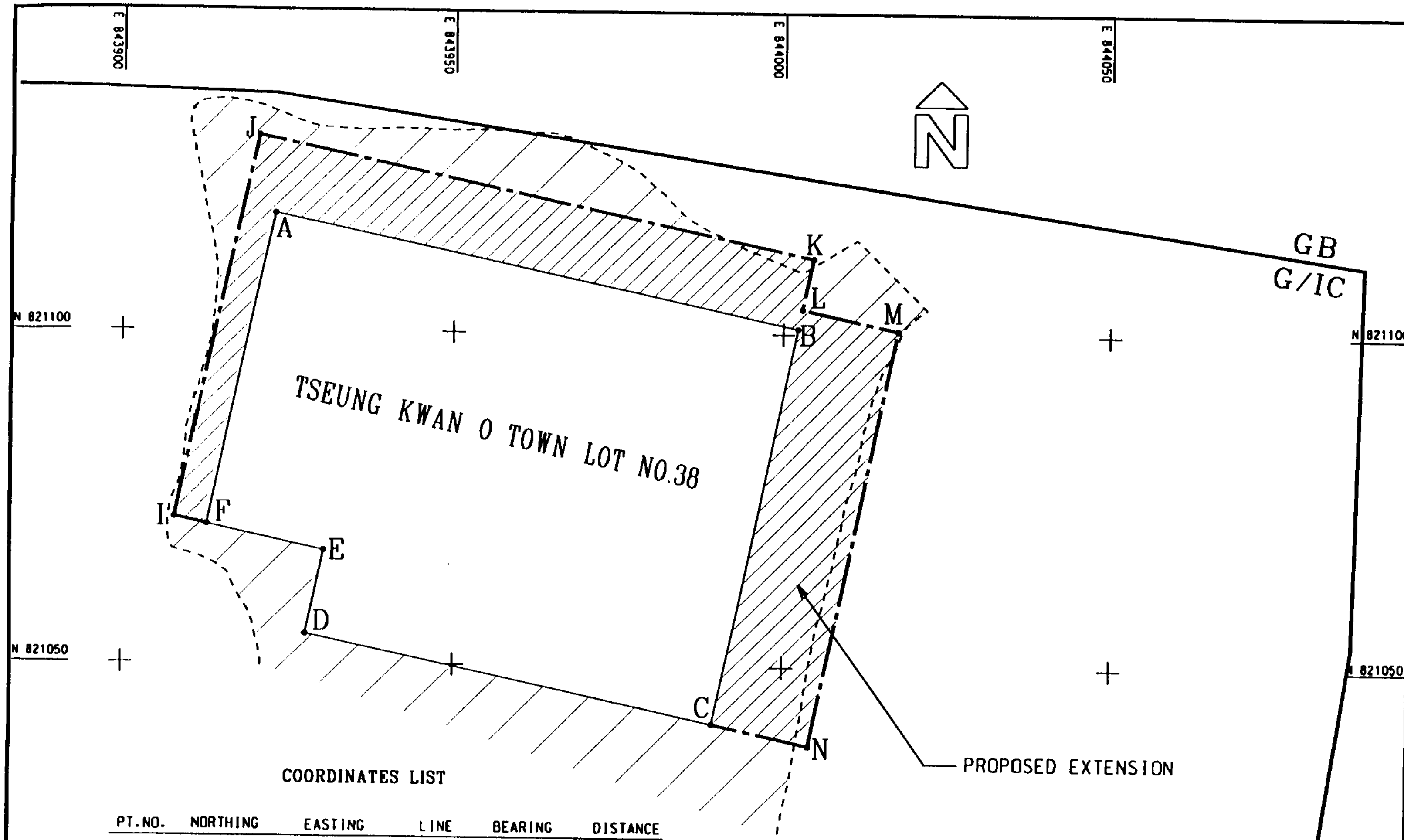
PREVIOUS EIA REPORT

The previous approved EIA report Tseung Kwan O 400kV Substation – Environmental & Visual Impact Assessment (October 1992) is attached in the Appendix 6.

Please note

The large-scale layout plans can only be viewed at the EIAO Register Office.

APPENDIX 1



COORDINATES LIST

PT.NO.	NORTHING	EASTING	LINE	BEARING	DISTANCE
A	821117.940	843923.080			
B	821100.850	844002.260			
C	821041.220	843989.390			
D	821054.510	843927.810			
E	821067.220	843930.550			
F	821071.020	843912.960	F - I	282.1136	5.000
I	821072.076	843908.073	I - J	12.1016	59.000
J	821129.750	843920.512	J - K	102.1049	86.000
K	821111.605	844004.576	K - L	192.1026	8.000
L	821103.785	844002.889	L - M	102.1037	15.000
M	821100.621	844017.552	M - N	192.1032	64.004
N	821038.056	844004.053	N - C	282.1034	15.000

REV.	DATE	INITIAL	DESCRIPTION
A	08/07/99	H.F.L.	PROPOSED BOUNDARY REVISED
--	09/06/99	H.F.L.	FIRST ISSUE

中華電力
CLP Power

MAJOR PROJECTS/
PROJECT MANAGEMENT - EAST

PROJECT : 04 490

TITLE:
PROPOSED EXTENSION
TSEUNG KWAN O TOWN LOT NO.38
PROPOSAL 'B'

1980 HONG KONG METRIC GRID SYSTEM
HONG KONG PRINCIPAL DATUM

SCALE: 1:1000	DATE OF SURVEY: -----
SURVEYED BY: N.A.	DRAWN BY: H.F.LO
CHECKED BY: K.C.HUNG	APPROVED BY: K.C.HUNG

MAJOR PROJECTS / PROJECTS SUPPORT

DRG.No.: 04490/RF1400-02A

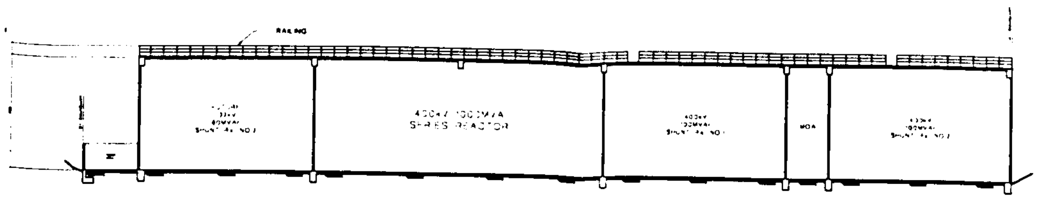
NOTES:

REF. PLANS:

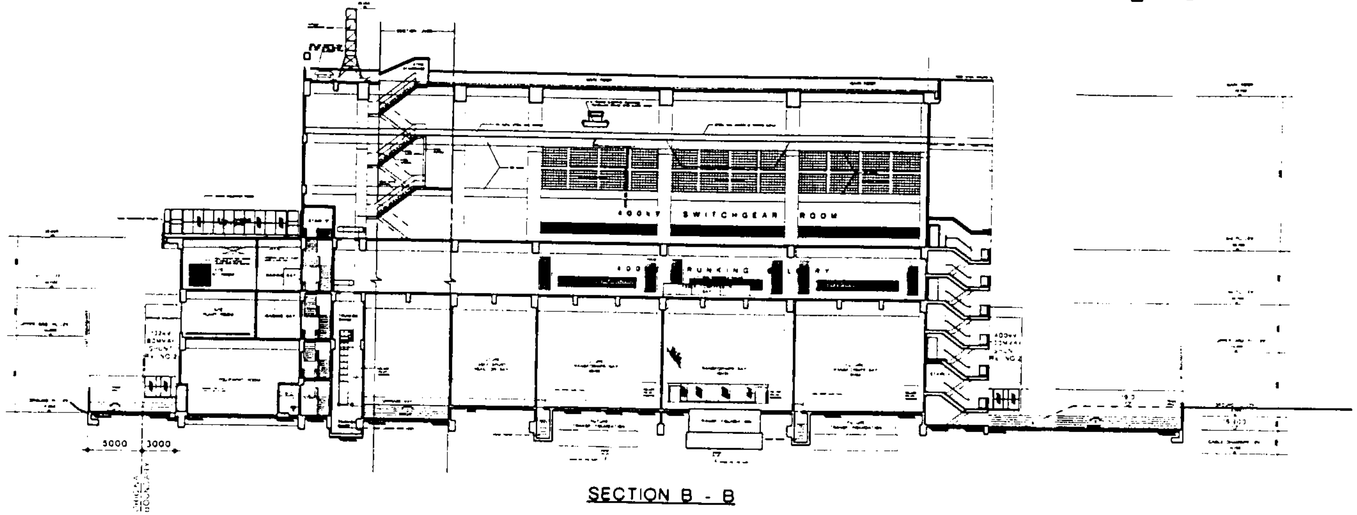
(1) SK 3150-SO
(2) SK 3150-DF
(3) L/TKO-8/2A
(4) TKE S/S LAYOUT PLAN WITH GIVEN DIMENSIONS.

DISK NO. : DISK137/DWG140A2.ARJ

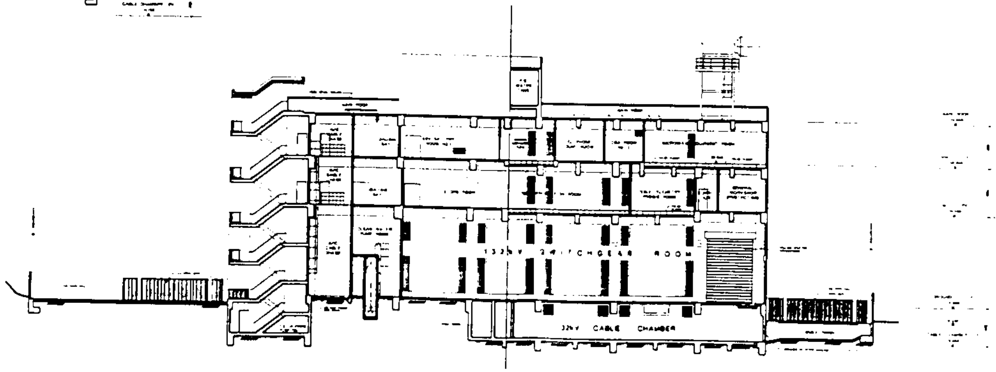
d:\felix\dgn\rf1400\dwg140a2.dgn Sep. 27, 1999 16:40:22



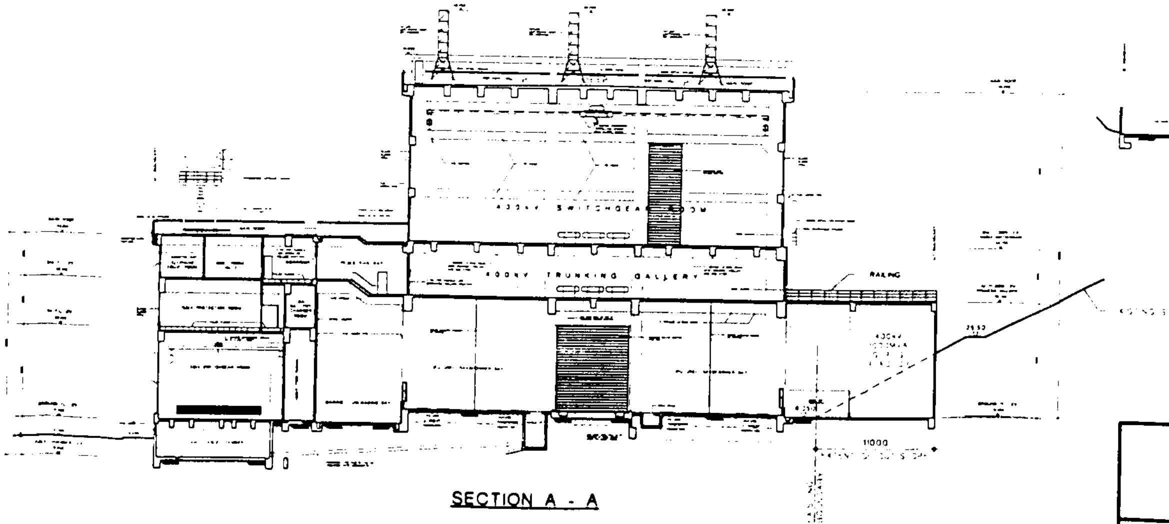
SECTION D - D



SECTION B - B



SECTION C - C



SECTION A - A

中華電力
CLP Power

DRAWN	KKHO	DATE	14.12.99
CHECKED	S.W.TAI	APPROVED	
SCALE	1 : 500	SHEET(S) IN SET	2
RESPONSIBLE DEPT	MAJOR PROJECTS		

INITIAL: A B C D E F G H J K L

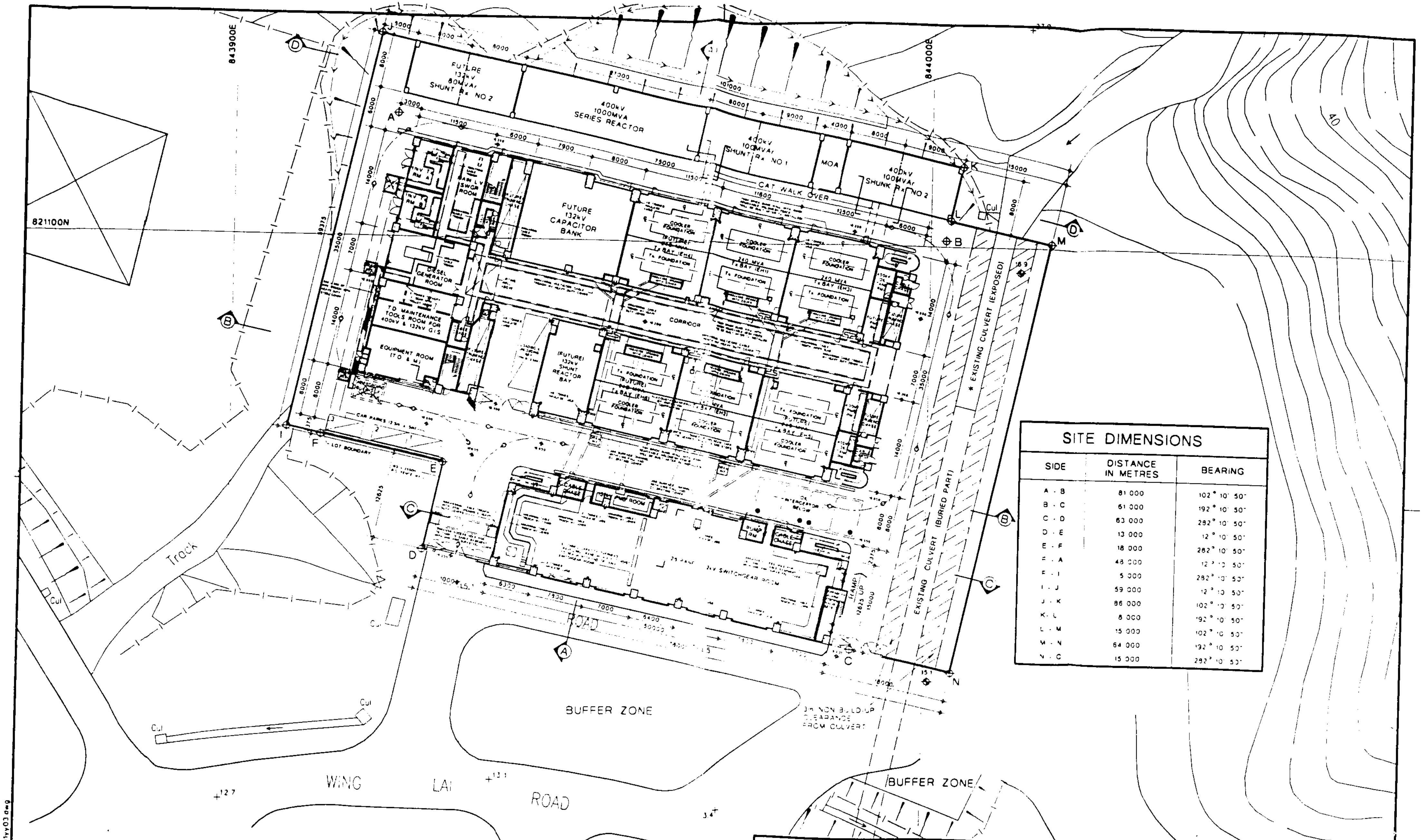
TITLE: TSEUNG KWAN O 400kV SUBSTATION EXTENSION LAYOUT (ALT. D)

PROJECT NO 24 490 | CONTRACT NO

DRG NO T / T K E / 1 0 2 5 0 / D / E 3 3 / 3 0 2 5 / 0 2 / - / S

0 50 100 150

Plotted 17.12.1999 16:41 10t-yz03.dwg



SITE DIMENSIONS

SIDE	DISTANCE IN METRES	BEARING
A - B	81 000	102° 10' 50"
B - C	61 000	192° 10' 50"
C - D	63 000	282° 10' 50"
D - E	13 000	12° 10' 50"
E - F	18 000	282° 10' 50"
F - A	48 000	12° 10' 50"
F - I	5 000	282° 10' 50"
I - J	59 000	12° 10' 50"
J - K	86 000	102° 10' 50"
K - L	8 000	192° 10' 50"
L - M	15 000	102° 10' 50"
M - N	64 000	192° 10' 50"
N - C	15 000	282° 10' 50"

NOTE

1. * EXPOSED PART OF THE EXISTING CULVERT TENTATIVELY SHOWN SUBJECT TO DETAIL DESIGN AND AS-BUILT VERTICAL PROFILE OF THIS CULVERT
2. 3m NON-BUILD-UP CLEARANCE AT BOTH SIDES OF CULVERT IS REQUIRED

中華電力 CLP Power

DRAWN	KKHO	DATE	14-12-99
CHECKED	S W TAI	APPROVED	
SCALE	1 : 500	SHEET(S) IN SET	2
RESPONSIBLE DEPT	MAJOR PROJECTS		

REVS: A B C D E F G H J K L

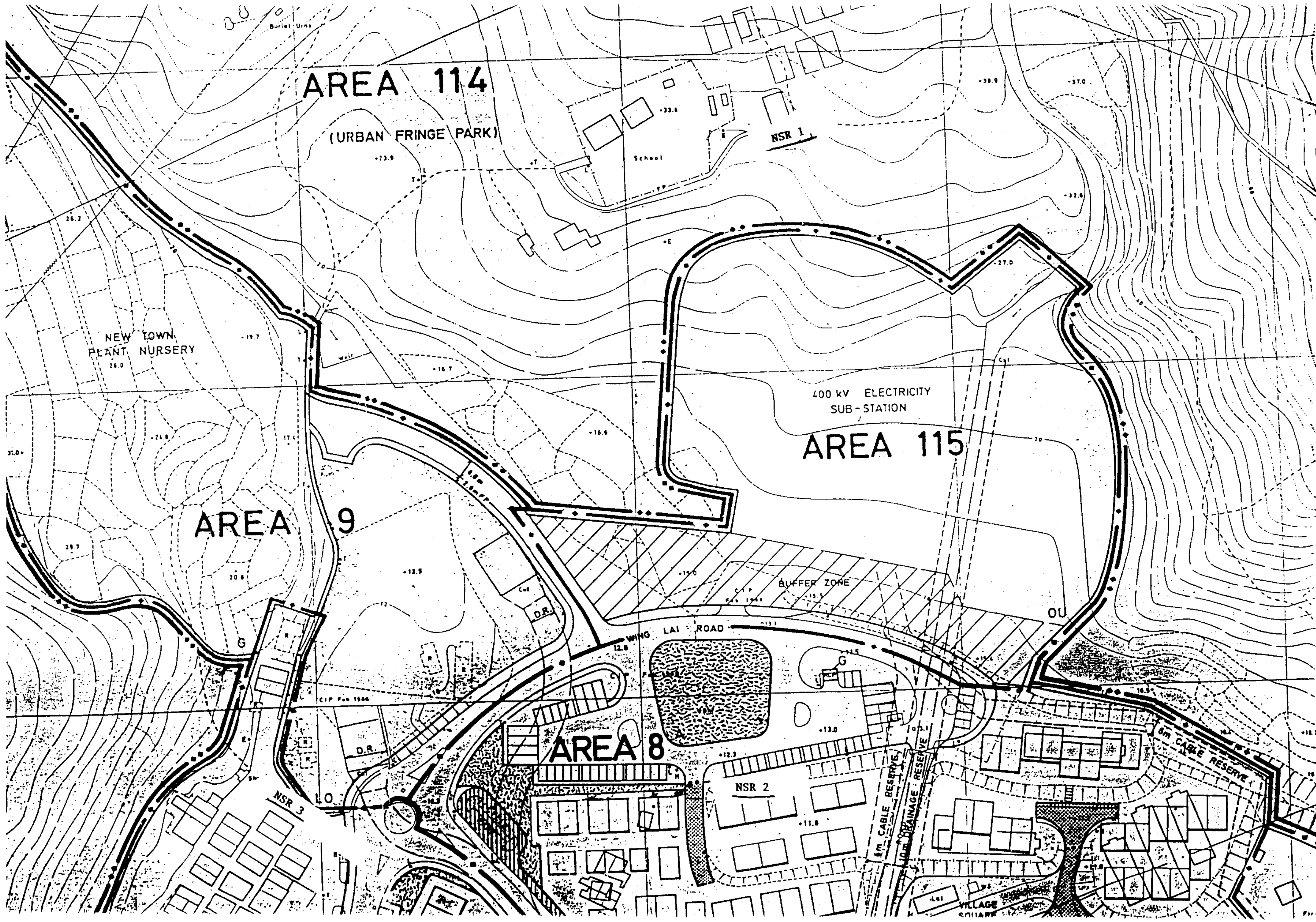
TITLE: TSEUNG KWAN O 400kV SUBSTATION EXTENSION LAYOUT (ALT. D)

PROJECT NO 04 490 — CONTRACT NO

DRG NO T K E 1 0 2 5 0 D E 3 3 3 0 2 5 0 1 S

Plotted 17.12.1999 16:19 1001vy03.dwg

APPENDIX 2


AREA 114
(URBAN FRINGE PARK)
Burial Urns
School
NSR 1
NEW TOWN
PLANT NURSERY
400 kV ELECTRICITY
SUB-STATION
AREA 115
AREA 9
BUFFER ZONE
WING LAI ROAD
AREA 8
NSR 2
NSR 3
6m CABLE RESERVE
10m DRAINAGE RESERVE
VILLAGE SQUARE

APPENDIX 3

Our ref: WR/L0320/99/PCL/YMC
(CFS No. 800-04)
Your ref: (136) in ED(TW)G/13II

File F1.3

中華電力
CLP Power

西區
香港九龍深水埗福華街二一五號三樓
West Region
3/F Shamshuipo Centre, 215 Fuk Wa Street,
Kowloon, Hong Kong
電話 Tel (852) 2678 6260
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網頁 Internet www.clpgroup.com

12 January 1999

Tsuen Wan District Education Office
Education Department
9/F. Tsuen Wan Government Offices
38, Sai Lau Kok Road
Tsuen Wan
N.T.

By fax (24981923) and post

Attention: Mr. K.L. Liu

Received by
Installation O&M Standards
Date 13 JAN 1999
File No.

Dear Sir,

Ex-Premises of CCC Kei Lei Primary School at Lei Muk Shue Estate
Estate School No. 1, Lei Muk Shue Estate
Kwai Chung, N.T.

We refer to your letter ref. (136) in ED(TW)G/13II dated 5 January 1999 concerning the effects of the electric cables, pylons and Lei Muk Shue 400kV substation on the health of the pupils and the staff of the captioned school premises.

As a standard practice, CLP carries out electric and magnetic field (EMF) measurement together with EMSD in high voltage system on a half yearly basis. The recent measurement was taken around the outer fence of Shatin 400kV substation (very similar to Lei Muk Shue 400kV substation) and nearby 400kV pylons on 10 September 1998.

Based on the measurement results, Shatin 400kV substation complies with the recommended limits of electric and magnetic fields due to equipment carrying high voltage current, as stipulated in Chapter 7 of the Hong Kong Planning Standard and Guidelines. Past measurements carried out on transmission system of CLP indicated that the associated electromagnetic fields were only a fraction of the Guideline limits.

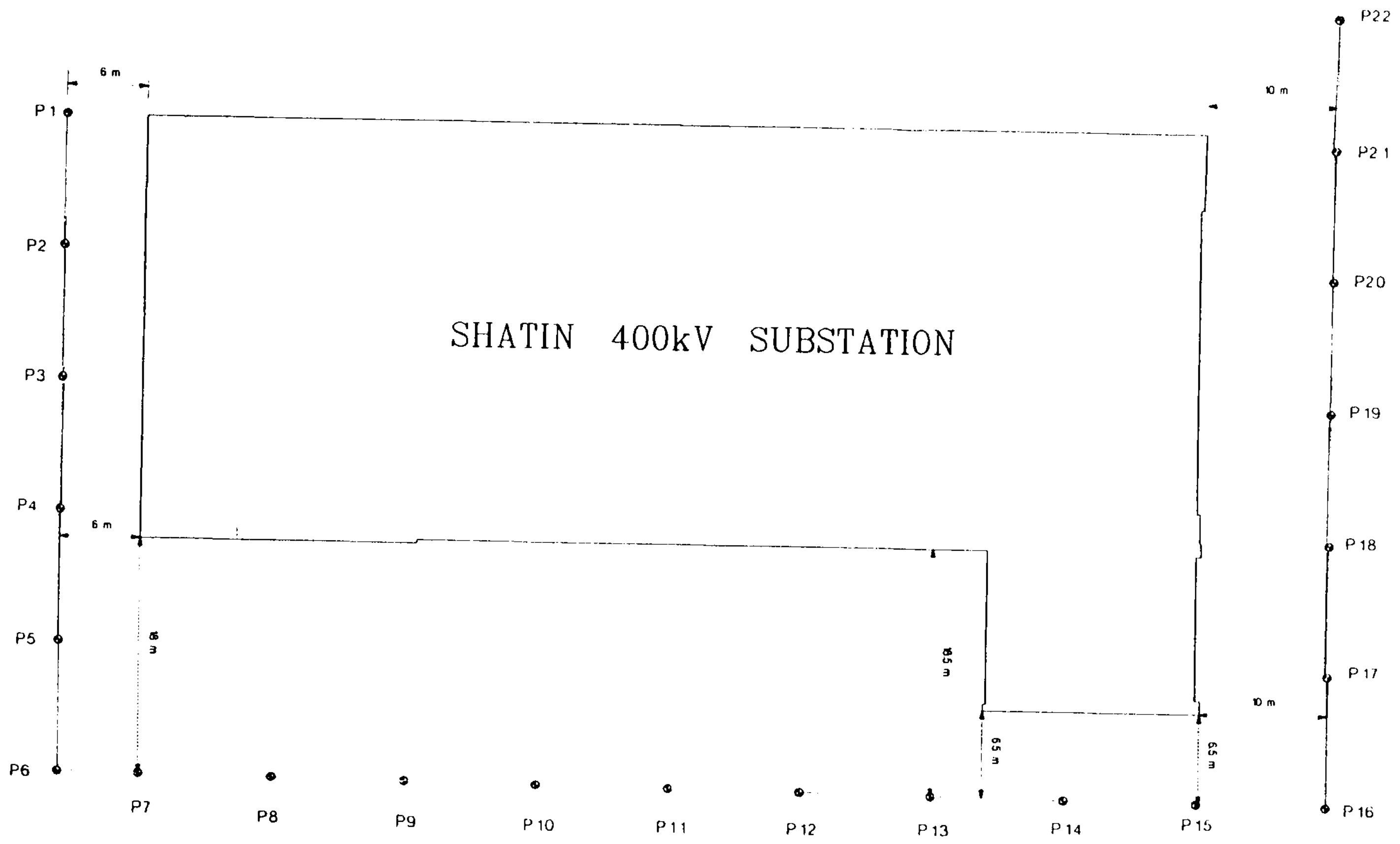
Should you require further information, please do not hesitate to contact the undersigned on 26786828.

Yours faithfully,
For and on behalf of
CLP Power

P.C. Lo
Transmission Operations Manager – West

15/1/99

b.c.c. Mr.Y.K. Lau/IOMS Manager
Mr.S.L.Kwan-RRM/West
Mr.P.C. Lo/Mr. Y.M. Chung
800-04



SKETCH OF ELECTRIC AND MAGNETIC FIELDS MEASURING POINTS AT SHATIN 400kV SUBSTATION

DATE : 10/09/1998

LEGEND .

MEASURING POINT

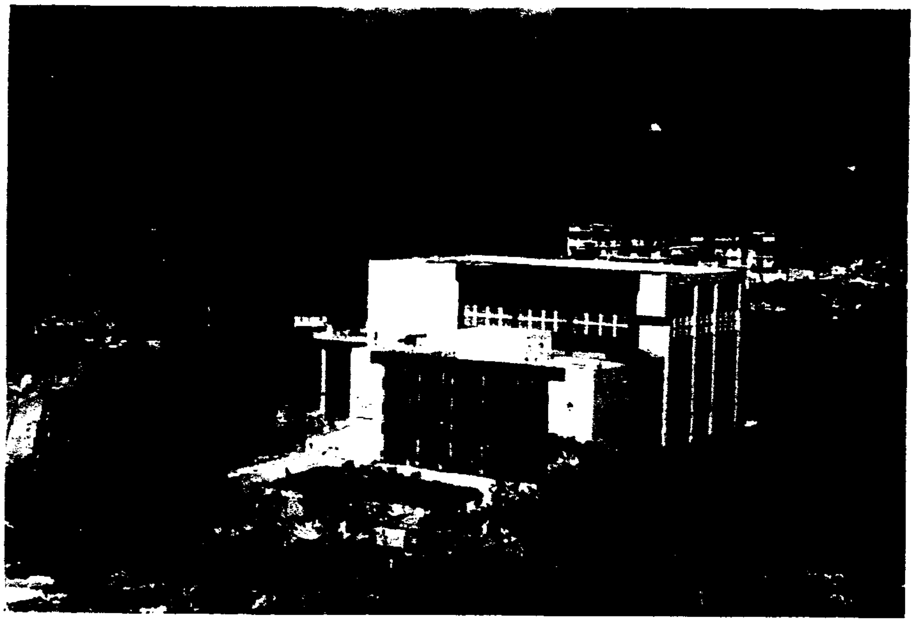
SCALE 1 : 400

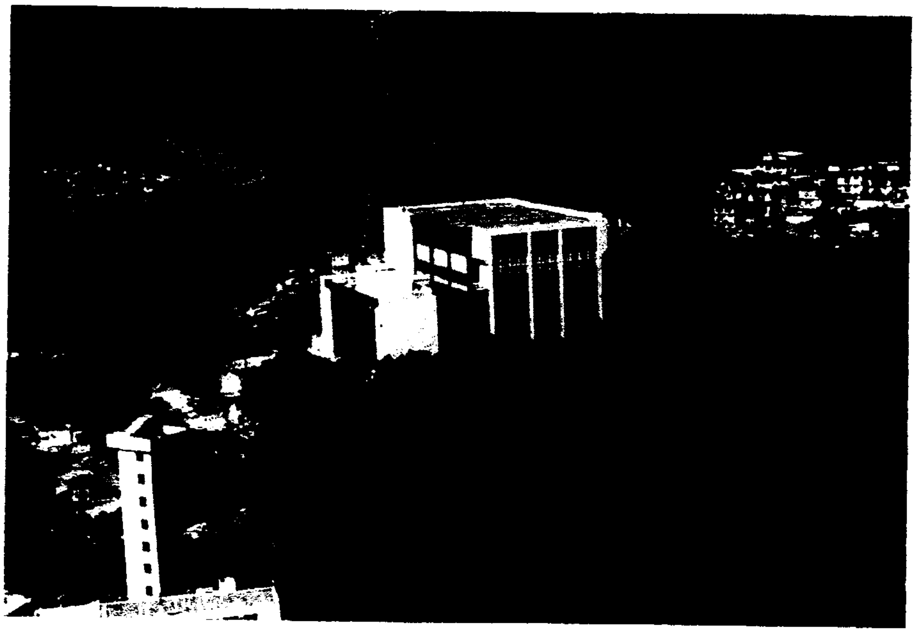
EMF Measurement Result

EMF measurement along the perimeter of Shatin Substation

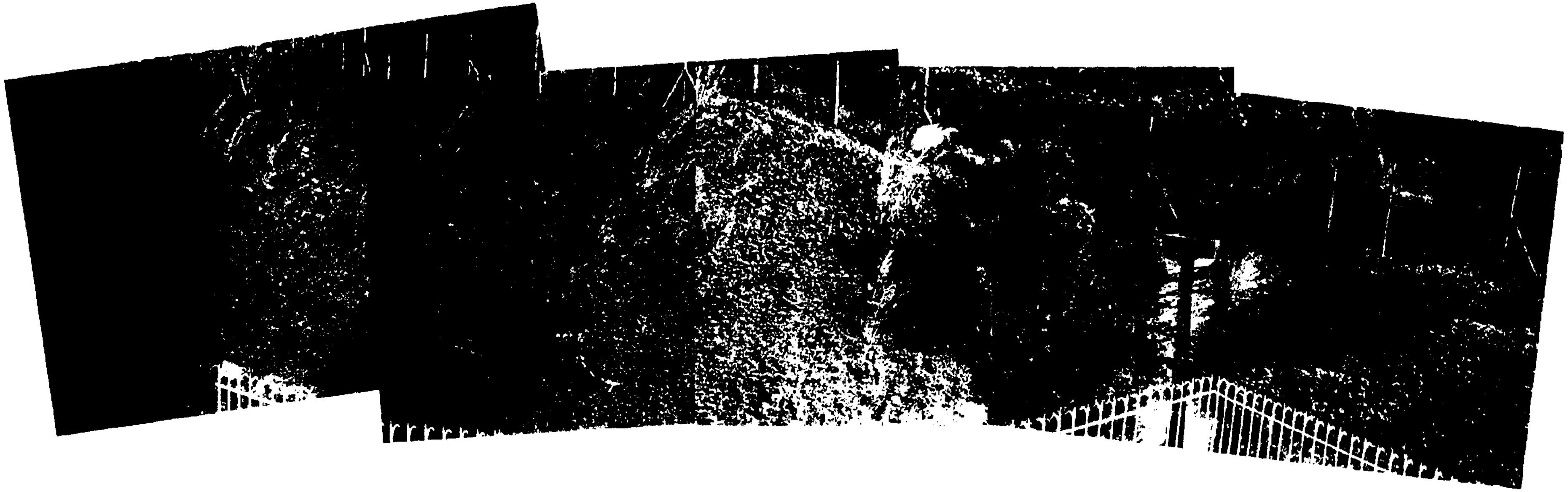
Measurement Points	Electric field (V/m)	Magnetic Field (mG)
P1	3	27.6
P2	4	34.8
P3	4	31.6
P4	6	26.6
P5	7	16.5
P6	5	11.0
P7	6	12.0
P8	7	20.3
P9	4	27.1
P10	6	23.1
P11	6	23.5
P12	6	35.9
P13	3	46.9
P14	4	33.3
P15	3	65.2
P16	3	52.6
P17	6	31.4
P18	7	17.6
P19	7	8.9
P20	6	13.5
P21	3	13.5
P22	3	10.0

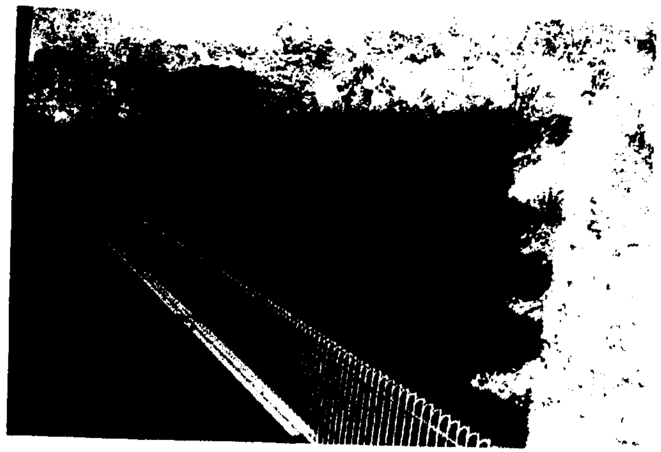
APPENDIX 4



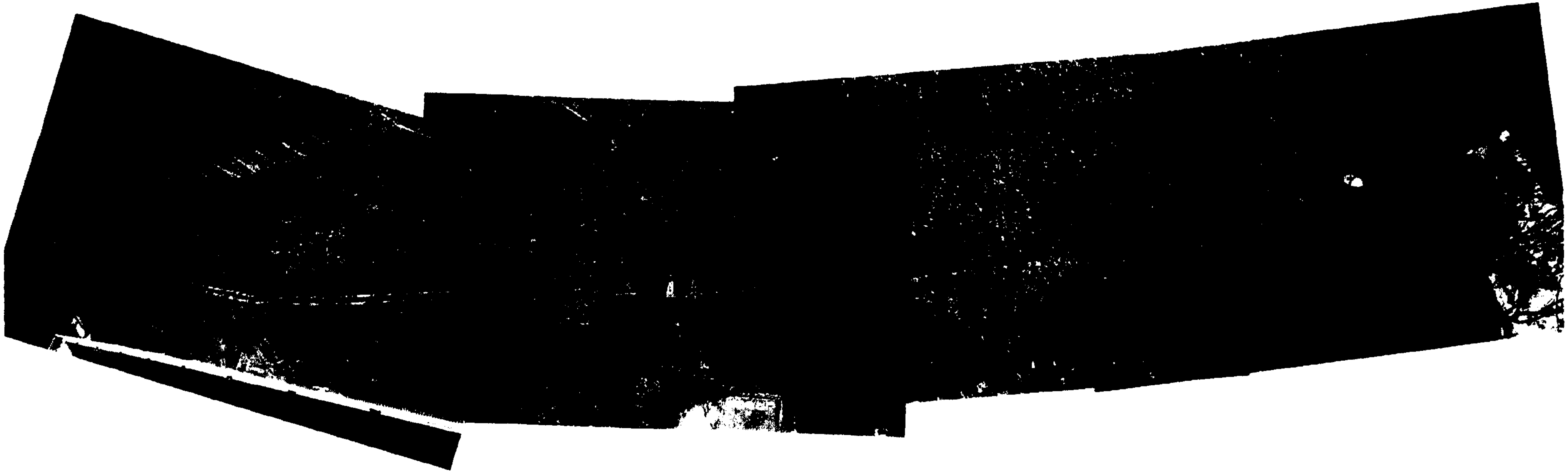


Front View of Tseung Kwan O 400kV S/S from Po Lam Estate

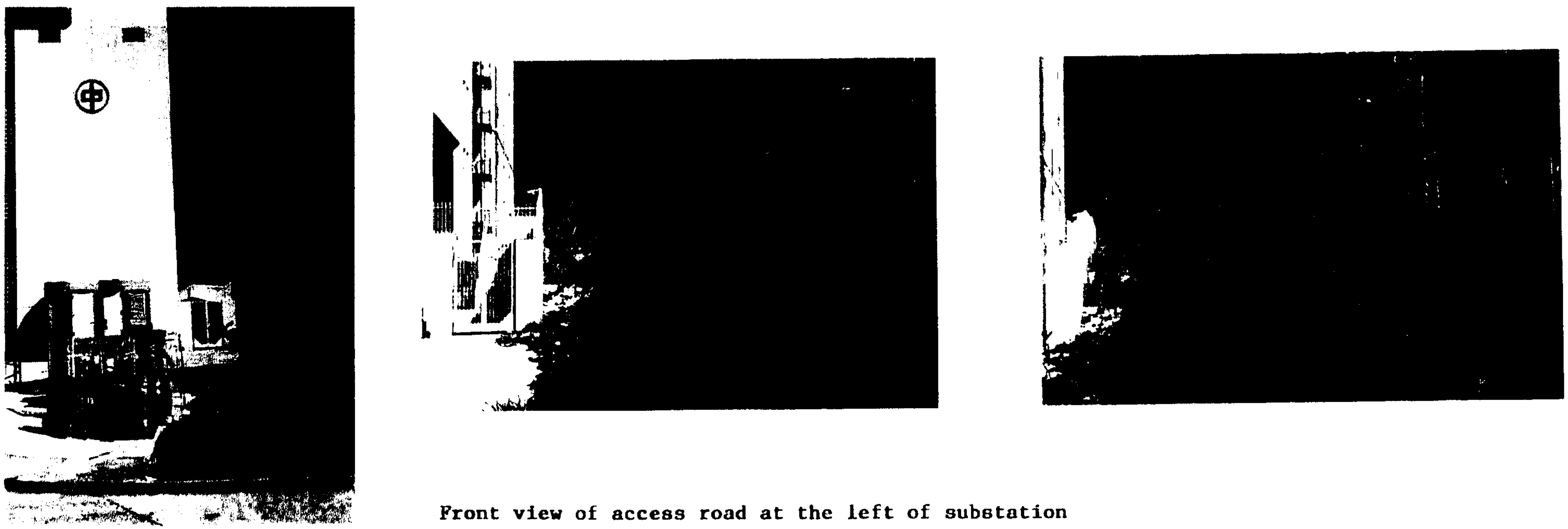




Top-view of slope at the back of substation

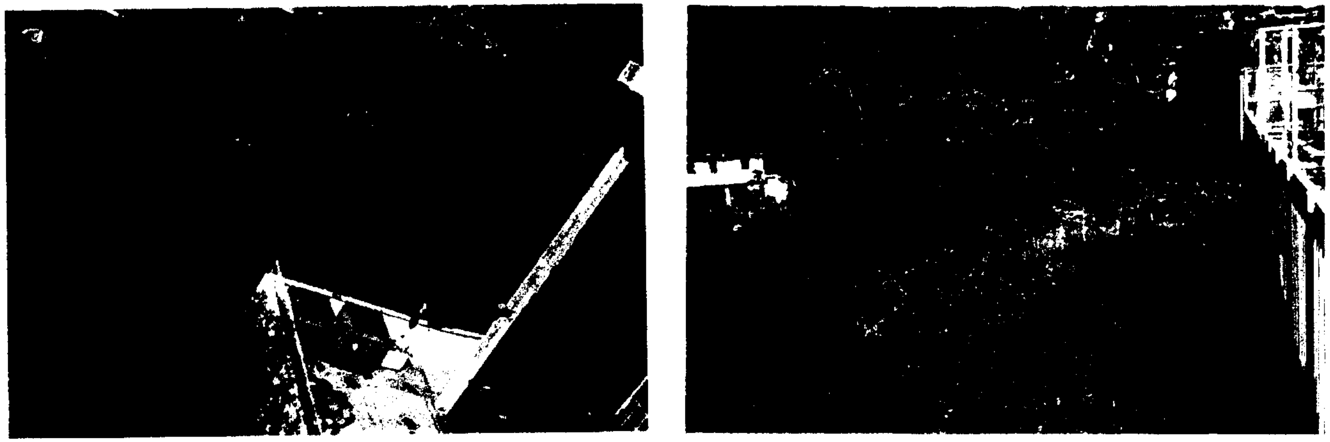


Top–view of access road at the left of substation



Front view of access road at the left of substation

Access road at the right of substation



Top-view of access road at the right of substation

Front view of access road at the right of substation

APPENDIX 5

APPENDIX 6

China Light & Power Company Limited

TSEUNG KWAN O 400 kV SUBSTATION

Environmental and Visual Impact Assessment

Final Report

Transmission Projects Department

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ENVIRONMENTAL AND VISUAL IMPACT ASSESSMENT

TSEUNG KWAN O 400kV SUBSTATION

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ENVIRONMENTAL IMPACT ASSESSMENT
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1. INTRODUCTION

1.1 Background

In order to aid the formal site reservation of area 115B for Tseung Kwan O Substation, China Light and Power Company Ltd (CLP) was initially requested by the Hong Kong Government to produce a Noise Impact Assessment Report and a Visual Impact Assessment Report for the substation development. However in subsequent meetings with the District Planning Office and the Environmental Protection Department, it became clear that a full environmental impact assessment was needed. It was agreed that a consolidated report incorporating the visual and noise aspects with other environmental issues would be produced.

A report on the noise impact of the proposed Tseung Kwan O Substation was issued in March 1990, followed by a supplementary report in December 1990. Approval of the Noise Impact Assessment was given in early 1991.

A preliminary EIA report was submitted to the EPD on June 12, 1991, and wide ranging comments were received from various Government Departments following its circulation to them. Some of these covered detailed points which had been envisaged for the final report. Clarification of these and subsequent comments ensued and a supplementary visual impact assessment report was issued on December 19, 1991. The EIA/VIA reports were finally approved on March 30, 1992.

This is the final EIA/VIA report and it demonstrates that every effort will be made to minimise any impact on the environment. It combines the Noise Impact Assessment Report, previously approved by Government, and the preliminary EIA and supplementary VIA reports in one document.

This report is specific to, and covers only, the substation development. The overhead lines and towers described herein are mentioned purely for the sake of completeness. A Government Steering Group has been set up to study the 400kV transmission links associated with the Proposed Black Point Power Station. The double circuit overhead line which is proposed to be installed from Tsz Wan Shan to this substation comes under the jurisdiction of this steering group.

1.2 Justification for the Substation

The bulk of the electricity demand of the East Kowloon area from Kai Tak and Tsz Wan Shan to Tseung Kwan O is supplied from the 400kV substation in Tsz Wan Shan. From current load forecasts, the estimated loading of Tsz Wan Shan Substation would be approximately 1200MVA and 1300MVA in 1995 and 1996 respectively.

The planning criterion for establishing new 400kV substations is that the loadings of existing 400kV substations (each of which can accommodate up to six 240MVA transformers) should be restricted ultimately to around 1000MVA as far as practicable. This 1000MVA limit is set to avoid widespread loadshedding on a catastrophic loss of a 400kV substation (or the circuits feeding it), and to ensure that the subsequent restoration of supply would be within the capacities of neighbouring substations.

It can be seen from the forecasts that the loading at Tsz Wan Shan Substation exceeds the 1000MVA planning criterion in 1995. The loading in 1996 also exceeds the total firm capacity of 1200MVA (i.e. the capacity of the remaining five transformers at Tsz Wan Shan should one of the six 240MVA transformers be out of service). As neighbouring 400kV substations (e.g. Tai Wan) will also be heavily loaded, relieving Tsz Wan Shan by transferring part of its load to other 400kV substations via new 132kV circuits would not only be expensive but also impractical. A new substation will, therefore, be required in 1996 to relieve the heavily loaded Tsz Wan Shan Substation. CLP proposes to build this new substation in Tseung Kwan O.

1.3 Scope of the EIA/VIA Report

This report describes the facilities which are to be developed at the site under consideration, discusses the background leading to the requirement of the substation, and addresses and examines the environmental impacts which are likely to result from the development of the substation. Where the impact is significant, ameliorative measures will be incorporated into the design in order to minimise the impact.

Specific areas covered are building design, landscaping approach, electro-magnetic effects and the transmission connections into the substation. It is not the intention of this report to discuss in detail the 400kV overhead lines associated with the development as this will be the subject of a separate study and report which will be submitted independently. The Tsz Wan Shan-Tseung Kwan O 400kV line has been included with the Black Point Transmission System for route investigation and selection.

Noise Impact and Supplementary Reports were submitted to the Director of Environmental Protection in May 1990 and January 1991 and were duly accepted by the DEP subject to certain comments. The reports have been amended accordingly and are summarised in this Consolidated Environmental Impact Assessment Document. Supplementing this report are a scale model, several photo-montages and an artist's impression of the substation and the surrounding environs.

2. THE PROPOSED DEVELOPMENT

2.1 The Substation Building Design

The building design is the result of detailed research and development over a series of 400kV substations which CLP have built over the years. The aim was to produce a design which is functional, economic, does not require much land nor has an adverse impact upon the environment. A multistorey design was adopted in order to maximise land utilisation whilst the substation was broken up into compact blocks to minimise the visual impact.

Certain constraints are evident. The position of the terminal tower must be fixed relative to the line landing platform to provide safe electrical clearance under the most severe wind conditions.

Adequate access must be provided to allow the movement of heavy plant and equipment; provisions must be made for all services and also for the distribution of multiple 132kV cable circuits to primary feeder substations.

The resultant building design must be compact yet functional to house extremely complex and sophisticated equipment with adequate provisions for maintenance access and facilities for all testing procedures.

The proposed site, the general layout of the building and tower position are shown in Appendix 1, Drawing TKE 10250 D E33 3015 01 - S.

2.2 Major Plant

The substation is based on CLP's standard philosophy for 400kV substations and as such the main building will be designed to ultimately accommodate six 240MVA 400/132kV transformers. Initially three transformers will be installed in 1996, the remainder will be installed progressively in response to the demand for electricity. Total plant which will be installed ultimately is as follows:

- 8 x 1½ breaker 400kV switchgear bays to accommodate a full set of 400kV metalclad SF_6 insulated switchgear.
- 29 x 132kV circuit breakers for the connection of outgoing circuits
- 2 x 80MVAr 132kV shunt reactors for compensation purposes.
- 2 x 80MVAr capacitors for compensation purposes.
- 6 x 240MVA, 400/132kV transformers

Space has also been allocated for building an adjoining block which will be used to house the 400kV shunt and series reactors associated with the 400kV cable circuits which will be connected to the substation in the future.

A diesel generator of about 500 to 700kVA rating will also be installed in the substation. This is an emergency generator and will only be used in the event of a complete power supply failure in the area when alternative supplies from other substations are not available. The generator will normally be tested for fifteen minutes every month, and for a longer period once a year.

A set of detailed layout drawings for the substation showing the utilisation of the space within the development is included as Appendix 2, Drawing no: TKE 10252 D E33 3011 Sheets 1 to 8

2.3 Incoming and Outgoing Circuits

The substation will be fed by a double circuit 400kV overhead line from Tsz Wan Shan Substation. The lines will terminate at a terminal tower on the west of the substation. From the tower, the conductors will land onto interface equipment on a platform located at the trunking gallery level of the building and connected to the switchgear in the building via SF_6 bus trunking.

Seven outgoing 132kV circuits will be installed by 1998 to feed the load of Tseung Kwan O development and to relieve the loading at Tsz Wan Shan. These circuits will all be underground cables either direct buried or installed in cable tunnels near the vicinity of the substation. These cables are of proven design and will have no effect on the environment. By virtue of their underground installation, the visual impact will be nil.

2.4 Construction Programme

It is proposed to start site activities in the last quarter of 1992. The revised preliminary programme for the construction of the substation is shown in Appendix 3, and is based on the requirement to commission the substation by the 1st April 1996. This requirement dictates that site formation works should commence in December 1992 and piling works should commence in February 1993 for completion of the substation buildings and services in January 1995.

3. ENVIRONMENTAL IMPACT.

The environmental impact which needs to be addressed for this substation development can be divided into five main issues:

- atmospheric emissions
- liquid effluent
- noise
- broadcast and telecommunications
- electromagnetic fields

One of the requirements mentioned in the EIA guidelines was the ecological impact of the development. These are issues which affect the ecological resources of the area i.e. loss of habitat through air emission, sewage discharge or land use.

Clearance of natural vegetation will be minimised as far as possible. There are no big old trees within the substation site. Felling of some small trees and scrub is anticipated at the buffer zone near Wing Lai road to make way for construction of access roads to the substation. Once construction works are completed the area surrounding the substation will be landscaped to restore as much vegetation as possible to the area. As can be seen later in this section, emissions and effluent discharge from the substation are virtually non-existent. The ecological impact is, therefore, not examined in this report.

The main concerns are those issues which relate to human health and to disturbance and nuisance i.e those that may affect the health and well being of the people living in the vicinity of the proposed substation. These issues are described in more detail as follows:

3.1 Atmospheric emissions

3.1.1 Construction Phase

The source of potential impacts are dust from excavation, from transportation of excavated materials and from construction activities at site. To minimise the potential impact of fugitive dust emissions during construction, good site management and house-keeping practices will be adopted. The steps which would be taken would include :-

- Covering of bamboo scaffolding structure with canvas.
- Erection of hoardings along site boundaries.
- Spraying water on site area to minimise wind-borne dust.
- Spraying water on truck tyres to minimise dust problems outside site.
- Removing loose unwanted material from site as soon as possible.

The current contract conditions for CLP's substation construction include a requirement for the contractor to implement stringent dust suppression measures, in accordance with EPD guidelines. Similar conditions will be applied to Tseung Kwan O Substation. Adherence to these conditions should ensure that dust impacts are minimised.

3.1.2 Operational Phase

There are no continuous or intermittent processes or activities during normal operations which would give rise to emissions to the atmosphere.

In order to operate the substation, it is necessary for a low voltage supply to be provided to the building for all the required auxiliary supplies, lighting etc. This is obtained from the area electricity supply via a local transformer. For security reasons, the substation will also be provided with alternative sources of supply from neighbouring substations. In the event of a fault causing a break in the main supply to Tseung Kwan O Substation, the back-up supply will take over in order to maintain the auxilliary supply to the substation. If both the main and back-up low voltage supplies were to fail then the substation's standby emergency diesel generator would be operated under emergency conditions for short periods of time until the fault was rectified.

The diesel generator would have a maximum rating of 700kVA and would be similar to that accepted at the Shatin 400kV Substation. When in operation it would consume a maximum of 105 litres per hour of diesel oil with a sulphur content not exceeding 0.5%. The waste combustion gases would be discharged through two 200mm diameter stacks at a height of approximately 5.65 metres above ground level and at a temperature of approximately 450°C. The diesel generator would be operated under test conditions for 15 minutes only per month with a supplementary, longer test of about 3 hours duration once per year.

Prior approval will be obtained from the relevant authorities for the installation of the generator and the outlet(s) of which will be located more than 5 metres from any place accessible by the public or any openable window or fresh air intake on the building or any adjacent building. The outlet will also be over 5 metres above ground level and the combustion gases will be discharged vertically upwards and not into an "enclosed well" or courtyard.

The design will take into account EPD guidelines to ensure strict control of atmospheric emissions, and will comply with FSD regulations to ensure safety.

3.2 Liquid effluent

3.2.1 Waste Disposal

As an electricity substation forming part of the 400kV transmission system the operations within the Tseung Kwan O building will be automatic, continuous and not subject to any process flows. As a consequence during normal operations, no effluent will be discharged from the premises.

Operation of the substation will produce small quantities of waste hydrocarbon oils (insulation and lubrication oils). These will be removed from site in suitable containers for either re-cycling or disposal by combustion in the furnaces of one of the Company's power stations. Waste cleaning solvents used in plant maintenance will similarly be removed from site for re-cycling or combustion. In keeping with the general campaign world-wide, CLP are attempting to phase out the use of chlorinated solvents. If they must be used in the future, Government advice and assistance will be sought and any waste products will be processed via the Chemical Waste Treatment Facility under construction at Tsing Yi.

It is conceivable that occassional maintenance and safety checks on the transformers may give rise to a small, unforeseeable, spillage of the transformer oil onto the station floor. Any spillage will be retained within the station with the use of an oil interceptor which will be inspected on a regular basis and cleaned out when necessary.

There is a standing maintenance procedure within the Company to ensure that any transformer oil discharged into the oil-interceptor is removed in a safe and environmentally compatible manner. Copies of the relevant documents are already with the EPD under cover of a CLP letter[1] dated 30.5.1991. Oil interceptors have been judged by the EPD to not require licencing under the Water Pollution Control Ordinance[2].

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[1]Letter no: 231-69/91/L20 A. Ashton to K. W. Tsang

[2]EPD reference: 52/W1/C46 dated 5.6.91

3.2.2 Sewage Disposal

Although the substation is normally unmanned, the occasional attendance of an engineer for repairs, maintenance and safety checks has necessitated the inclusion of a toilet from which it could be determined there would be a flow of around 50 litres per person per day of foul domestic wastes whenever an employee was present for a full working day. This is the only sewage discharge from the substation and the toilet will be connected to a public sewer located nearby. On this basis it has previously been agreed with the Environmental Protection Department that an application for a Water Control Zone licence is unnecessary.

3.3 Noise

The six 240MVA 400/132kV transformers and two shunt reactors to be installed in the substation are all inherently noisy in nature once they are switched on.

Following an extensive field survey to explore the background noise climate in the vicinity of the proposed site, it has been established that the background noise levels fluctuated from 38 to 52 dB(A) during a typical night-time situation. Noise was predominantly from insects and from traffic along roads D5 & D2.

In determining a realistic night-time limit for the level of noise predicted to be emitted from the substation, a criterion of (BNL[3] + 5)dB was established using measured pre-existing background noise levels in the neighbourhood. The criterion permits a marginal increase of the lowest measured background noise which is considered reasonable in view of the Government's latest development plan of increasing urbanisation in the Tseung Kwan O New Town Area which will inevitably also raise the background noise level.

In order to avoid noise disturbance following the energising of the equipment, supplementary noise control measures have been recommended to be incorporated into the design of the proposed development. These measures include the fitting of acoustic partitions and enclosure type devices and the low noise design type fans.

On the basis of the above measures, it is predicted that the substation noise level at the nearest residences would be 40.8 dB(A) during a night-time situation. It is therefore concluded that noise disturbance from the substation will not occur at the facade of present or future planned noise sensitive developments.

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[3]BNL refers to the lowest Background Noise Level of 38dB(A) recorded at the site

Noise impact assessment report no: SSB/ES/R119-90 and supplementary report no: SSB/ES/R134-90 previously issued to the Government give full reference to the above. These reports are enclosed in Appendix 12.

3.4 Broadcast and Telecommunications

The effects of high voltage transmission lines to broadcast reception were investigated by Mr F. H. Wise, then Chief Telecommunications Engineer for the Hong Kong G.P.O. in 1983. As a result an "Informative Note" was published and some pertinent points are extracted in this section for reference.

There are three principal ways in which the development can affect broadcast reception and telecommunication services. These are :

- By shielding of the receiving point from the broadcast transmission.
- By causing reflections which may be picked up at the receiving point in addition to the directly received signals.
- By generation of electrical interference (or "noise") which may contain energy in the same frequency band as the broadcast transmissions.

Remarks are made on each of these three factors with specific reference to the situation at Tseung Kwan O.

3.4.1 Shielding due to the substation and power lines

At VHF and UHF broadcasting frequencies the shielding effect is small. That due to the high voltage wires is entirely negligible while that due to the support tower and building is significant only in the region within 100m of and immediately behind the towers as seen from the broadcast transmitting station. This loss of signal due to shielding is comparatively small and it tends to be significant only when the wanted broadcast signal is weak.

Typically, the loss is in the order 10dB. In the Tseung Kwan O area, there are few domestic premises likely to be affected in this way and the strength of the locally received VHF/FM and UHF/TV signals will be sufficiently strong to make this effect unimportant. It may be remarked that the effect of the power lines, their support towers and the substation in this context is very small compared with that due to the tall buildings typical to Hong Kong.

At the lower frequencies used for MF/AM sound broadcasting, the effect tends to be rather different. The concept of shielding in the optical sense of "obstructed view" no longer applies and some loss of signal occurs generally in the vicinity of the power line. In practice, this may mean within 50m of a tower or from the vertical plane dropped from any point along the high voltage line.

With regard to telecommunication, the radio paging, cellular telephone and mobile radio services are currently in the VHF and UHF bands, and owing to the small longitudinal cross section of the overhead wires, the shielding effect due to the power lines will be negligible.

The transmitter sites associated with the cellular telephone and paging services are in direct line of sight, within 1 km (transmitters located on Tsui Lam and Po Lam Housing Estates) of the proposed substation site. The shielding effect due to the lattice tower will be insignificant, however minor localized shielding due to the substation building may be encountered 50m North/East of the substation building.

The mobile radio services provided to the Tseung Kwan O area emanate from the transmitter site at Kowloon Peak which has a line of sight to the proposed substation and nearby residential areas. No shielding of the Kowloon Peak transmitter should be experienced by existing residential areas east of the proposed substation site.

3.4.2 Reflections

Tall structures sometimes cause significant echoes at VHF and UHF broadcasting frequencies. They are most likely to occur when the reflecting object is more strongly illuminated by the broadcast signal than is the receiving point. This may happen when the reflecting object is on local high ground whilst the reception point has a clear path to the reflecting object but a less clear path to the broadcast transmitter. The effect on television reception is to produce a "ghost" image, normally a little to the right of the main image as seen on the TV screen. Similar reflections may occur for VHF/FM radio but in this case the symptom is distortion of the sound. In practice, none of these effects is likely to occur to a significant degree.

The effect of reflections from the power lines on telecommunication services will be insignificant. Localized destructive reflection interference may be experienced from the Kowloon Peak transmitters within 50-100m of the substation building towards the Southwest, but it is of no consequence to the existing village areas located near the proposed substation.

3.4.3 Electrical Interference

High voltage distribution systems are sources of electrical noise which may produce interference to radio systems. There are several possible causes of this electrical noise and they include that caused at the generator station as well as sparking or corona discharge from the transmission line itself.

In general, the magnitude of the interference decreases with frequency. The result is that power lines do not normally contribute to interference to any significant degree at VHF/FM or UHF/TV broadcast frequencies. In the Tseung Kwan 'O' area where the broadcast signals are strong, any interference from the power lines would, therefore, most probably occur only under fault conditions in the high voltage distribution system.

At the lower MF/AM frequencies, some noticeable interference may occur but only close to the lines. This will tend to occur in those places directly under the lines where the broadcast signal is reduced for the reasons described in (i). The effect will be greatest for car radio reception where a rod aerial is used. For normal domestic reception using a loop aerial (ferrite rod) the effect of the interference will be rather less. In the Tseung Kwan O area, the line should not run very close to housing developments but in any area where it does, some interference is possible. Some alleviation may be obtained by careful orientation of the set so as to minimise its response to the source of interference.

Due to the fact that radio paging, cellular telephone and mobile radio users utilise the VHF and UHF bands, with FM modulation techniques, the influence of noise either generated naturally or by substation equipment should be negligible.

3.4.4 Conclusions

The nearest prime broadcasting installation to this substation site is along Kowloon Peak, which will provide an unobstructed line of sight to all current low rise residential establishments.

A field survey has been conducted recently confirming that the content and conclusion of the 'Information Note' by Mr. Wise is also applicable to the Tseung Kwan O area. Areas surrounding the proposed substation site are shielded from all commercial television broadcast transmitters except the Kowloon Peak translator. Observations carried out at the proposed substation site confirmed that residents in the immediate surrounds use the translator station at Kowloon Peak which is in the northwest direction.

The new substation building and landing tower will be built between village areas on the northern and southern sides at a distance of over 100m, maintaining an unobstructed view of the signal source from Kowloon Peak. It is therefore concluded that the proposed substation building and transmission lines will have negligible additional effect on the local broadcast reception.

3.5 Electromagnetic Field Effects

CLP is committed to providing electricity in a way that protects the health and safety of its customers and employees. The existence of electric and magnetic fields associated with power lines does not compromise this commitment.

Over the past few decades, the issue of possible health effects of electric and magnetic fields has generated a number of studies and reports. The weight of the evidence from those studies gives us confidence that we are providing electricity to our customers in a safe manner and that no changes to our present electric power delivery methods are warranted.

From time to time unsubstantiated media articles of an alarming nature inferring health risks are produced which, it could be argued, introduce unnecessary concern and cause stress to members of the public. Nevertheless, CLP regards all reports with respect and ensures that any such concerns raised are fully considered in the light of the data available from qualified scientific research projects and the subsequent reviews and overall assessments as compiled by recognised research bodies, Government or State Authorities and others.

In the meantime, CLP has carried out studies of its own installations to ascertain levels of electric and magnetic fields. The studies have shown that the measured and calculated field levels are well within the guideline limits issued by the International Radiation Protection Association (IRPA) in January, 1990.

The actual measured values from existing 400kV installations are shown on the attached graph (Appendix 11). The Tsz Wan Shan - TKO overhead line will have the same rating as the line upon which the measurements were taken. The loading condition at any point in time will depend on the supply demand from the substation, however the maximum load the circuit can carry, and hence the maximum field strength, will be similar. The loading of the lines at the time of measurement was 45% of the maximum. At its maximum rating the magnetic field strength is expected to be 10% of the IRPA limit.

The electric and magnetic field strengths decrease rapidly with distance from the line and the actual values at the school site, some 50m away, are extrapolated to be well below the guideline values of IRPA (less than 10% of the limit).

Actual readings taken at Tsz Wan Shan 400kV Substation which will be typical of the values expected at Tseung Kwan O Substation are included as Appendix 4. The equipment layout, installed capacity etc for the proposed substation are similar to those for Tsz Wan Shan 400kV Substation insofar as the electromagnetic fields are concerned. Since all electrical equipment in the substation is enclosed in metal enclosures, the screening effect reduces the electric field strength to a negligible value. The measured magnetic field is also within the guideline recommendations.

In its letter of 11 June 1990, CLP made a commitment to the Hong Kong Government to fully adopt the IRPA guidelines for existing installations as well as for new ones. This letter, together with the IRPA guidelines, is included as Appendix 5. From the two appendices it may be seen that the actual fields occurring under CLP's overhead lines and in her substations are generally an order of magnitude below the guideline recommendations.

4. VISUAL IMPACT

4.1 Overview

The proposed development of the Tseung Kwan O 400kV Substation will be situated 130m north east of the existing Tseung Kwan O Village. The substation site will cover a land area of about 124m x 77m and will comprise three key parts, namely:

a) 400kV equipment block (circa 30m high)
b) 132kV equipment block (circa 20m high)
c) future block (circa 20m high)

The three blocks will be arranged in a manner as shown in the photo-montages (Appendix 6). The close arrangement of the blocks, as well as providing a visually tidy and compact site, makes full use of the available land.

The surrounding area of the proposed site whilst on the fringe of an open rural aspect is basically suburban in character. With increasing "urbanisation" in the Tseung Kwan O region likely to continue, the suburban character of the surrounding land will also increase.

As shown in Appendix 6, whilst the local topography to the rear of the proposed substation consists primarily of steep hill slopes covered with trees and shrubs, the remaining area of Tseung Kwan O from the southern boundary of the substation to the Junk Bay shoreline is almost flat with scattered houses and temporary structures. In accordance with the Government's development scheme, the nearby temporary housing structures will be demolished and replaced by low rise village type housing in the future. In addition, there are also a number of newly built, 3-storey Spanish style residential blocks of flats located approximately 100m to the north of the substation in an elevated position overlooking the proposed substation site.

In order to diminish the direct view of the substation and to blend the appearance of the building structures with the existing suburban and rural background of the area, an extensive landscaping and planting programme of various tree and shrub species will be carried out on completion of the building works along the proposed substation boundary and around the site. This is described in more detail in Section 5 of the report. In addition, the external facade of the substation buildings will be treated selectively to harmonise with the surrounding environment in a similar manner to that illustrated in Appendix 7 of the artist's impression of the proposed development. Visual aspects to long overhead lines being drawn into the substation will be avoided and wherever possible any equipment will be enclosed or visually shielded. The final appearance will more readily resemble an administrative centre which is capable of forming an acceptable part of the future suburban townscape.

4.2 Sources of Potential Impact

The principal sources of potential visual impact are

i) The substation buildings which comprise a 30m high 400kV equipment block, a 20m high 132kV equipment block and a 20m high future reactive compensation block.

ii) An overhead line tower located 30m west of the substation block.

These are shown in drawing no TKE-10250-D-E3006-01 (see Appendix 1).

4.3 Sensitive Viewpoints

The principal sensitive viewpoints are restricted to the areas immediately south, south-south east and south-south west of the substation, ie., within a radius of 500m from the substation, as shown in Appendix 9.

The sensitive receptors within this visual envelope are :

- the residents of Tseung Kwan O village in area 7
- the future residents of Area 8
- the residents of the Pa Yan, Pa Toi and Pa Tak blocks in Po Lam Estate
- the residents of the north facing blocks of Tsui Lam Estate

There are two very small groups of receptor population to the north of the substation. One group comprises thirteen 3-storey dwelling houses between 50m and 100m from the substation, and the other is a group of houses in Rise Park Villas approximately 750m from the substation. Beyond these dwellings, views from the north and east, especially from Clearwater Bay Road, and the west are obstructed by the hills and ridges which forms an arc between Tai Po Tsui, Razor Hill and Tai Sheung Kok.

4.4 Extent of Visual Impact

The site lies within a circle of suburban type houses and high rise residential blocks as described in section 3; and direct view of the substation is restricted to the residents within this periphery. The substation will have no potential adverse impact on the recreational activities in the area, in so far as visual amenities are concerned, since it is not a recognised leisure or picnic area and there is no prominent road or trail in the hills directly beyond the substation.

The degree of impact on visual amenity was based on the quality of the existing views, as perceived by the receptor population described in section 4.3. This was related to the possible obstruction to the existing views caused by the substation development when viewed from a particular location, and, the existing overall setting as seen from the receptor's viewpoint.

The impact on the thirteen dwellings immediately to the north of the substation is considered to be moderate. This is due to the small receptor population and the presence of other intrusions in their direction of view, ie. the tower blocks of Po Lam Estate - there would be negligible conflict with the present visual setting. Although the substation is relatively close, it will be at a level of approximately 20m lower, i.e., only the top one-third of the substation will be potentially visually obstructive. The proposed mitigation measures will help attenuate the visual impact of the substation.

From Area 7 in the south-south west and Area 8 in the south, the substation complex will be viewed against a backdrop of hills which rises to a peak of 432m (Razor Hill). Because of the short viewing distance, the visual impact to these receptors is considered to be severe. Maximum mitigation measures will be required in order to minimise the visual impact of the substation.

The impact on the receptors in Area 14 (Po Lam Housing Estate) is considered to be moderate. When viewed from the high rise developments, the substation poses less of visual obstruction against the hilly background than would be to receptors in Areas 7 and 8. In addition, the substation will be viewed in the countext of the general visual setting of the surrounding area, i.e., the village development, fire station, schools, etc.

The visual impact to the receptors in Tsui Lam Estate will be low to moderate as the substation will, similarly, be less of a visual obstruction. There will also be minimal conflict with the existing visual setting, i.e., the village development, fire station, school and the high rise blocks of Po Lam Estate, when viewed from these high rise developments.

Finally, the visual impact from Rise Park Villas is considered to be low to negligible. From this high vantage point, the substation will not be a source of obstruction to the existing views, there will be minimal conflict with the existing visual setting from this location, and the impact of the substation is attenuated by distance.

4.5 Mitigation of Impacts

The substation will be designed in a similar compact style to that of existing 400kV substations. This will result in a group of functionally related buildings which by their nature will determine the architectural form.

There are three principal mitigation measures which will be applied to ensure that the visual impact of the substation is minimal. These are:

i) by designing the building structure such that its structural form, elements openings and solid panels will reduce the massiveness of its bulk.

ii) by designing the buildings such that the architectural finishes and colours will blend as far as possible with the surroundings

iii) by implementing an intensive landscaping and planting programme of various grasses, trees and shrubs along the substation boundaries and around the site.

The architectural aspects are described in the following sub-sections; landscaping treatment is described Section 5.

4.5.1 Structural Form

The plant and equipment for a 400kV substation are physically space demanding and will require a large building volume to house them. The facilities will be arranged in three separate blocks in accordance with their operational requirements. Whilst providing the required functional segregation of plant, this arrangement will also break up the building mass resulting in a less imposing fascade. The structural frame of the building will also be used to enhance its architectural features.

4.5.2 Architectural Finish and Colours

In addition to the use of the structures to break up the building mass, colours and suitable materials, such as ceramic tiles with metallic sheen, will be used to enhance the building appearance. In order to harmonise with the natural vegetation which forms the background of the substation buildings, neutral colours, such as, brown, tan, beige and grey will be considered as the main theme.

4.6 Conclusions

Great care will be taken during the detail design of the substation, to ensure that the visual impact of the completed substation is minimised. The visual impact should, however, be considered in the context of the future development of the Tseung Kwan O area as a whole.

As with other China Light and Power 400kV substations, the building will be designed to blend in with the surrounding environment. It shall be designed not only to serve the area as a functional substation but also as an integral part of the overall townscape. The combined effect of the structural features, the response of the proposed material finishes to light at various times of the day and the blending effects of the colour schemes, together with the landscaping features described in the following section, will result in a more visually acceptable building which will blend in more effectively with the surrounding suburban environment.

5. LANDSCAPING

The existing area environment is predominantly rural with a temporary storage compound, a few scattered vehicles repair workshops and an abandoned village-type primary school hidden amid a dense woodland between low rise village houses.

The topography consists of gentle slopes with a dense wooded ravine running along the foot of the slopes. This is featured with what appears to be abandoned terraced paddy or vegetable fields.

5.1 Existing Vegetation

The existing vegetative cover comprises of trees and shrubs, giving way to grass at higher elevations. The ravine woods consist heavily of various species of Ficus, Acacia, Pinus, Macaranga, Castanopsis, Sterculia, Schefflera, Litsea, Rhaphiolepis, Sapium, Liquidambar, Melastoma, Eurya, Mallotus and Bamboo. Surrounding the abandoned village school are Eurphoria longan, Acacia and Eucalyptus, Mallotus and many other amenity type plants. Along both sides of the roads are rows of Liquidambar formosana, Acacia Confusa, Cinnamomum camphora, Bauhinia purpurea & Melaleuca leucadendron which are growing successfully to blend in the dense wooded hillside ravines.

5.2 Landscaping Proposals

In order to minimise the visual impact of the substation, a comprehensive regime of landscaping treatment will be carried out.

All cut slopes will be immediately hydroseeded after formation works are completed. The hydroseeded slopes will then be allowed to become established. Excessively grown tall weed-type grasses would be weeded prior to the commencement of large-scale trees and shrubs planting.

The access road and the buffer zone area in front of the substation will be densely planted with rows of either heavy standard or standards of Liquidamber formosana, Cinnamomum camphora, Melaleuca leucadandron and/or Acacia confusa in order to match with the Governmental landscape treatment of the area. In addition to these species (comprising of about 40-50%), medium to large shrubs of approximately 50-60% of Nerium indicum, Thevetia peruviana, Mallotus paniculatus, Ligustrum sinensis, Malastoma sanguineum and Rhapiolepis indica will be mix-planted in the buffer zones at the entrance of the substation. These plants, after they are established and with follow-up maintenance, will give a dense coverage and reduce the hard visual impact of the entrance block.

The areas surrounding the substation will be similarly landscaped with dense vegetation so that they harmonise with the densely wooded ravines. The trees to be planted are recommended to be standards or heavy standards and shrubs are to be of 1 or 2 years old multi-items in order to get a quicker dense coverage within a shorter growing period. The planting would be randomized and mixed, with spacings of 2.5m x 2.5m for trees and 0.75m for shrubs between plants and between rows.

After having been established for about 1 or 2 years, the weaker plants would be thinned-out whilst missing failures would be replaced by new plants. The following lists of species composition are recommended :-

40% of Dominating species:-

a) Acacia confusa
b) Tristania conferta
c) Castanopsis fissa
d) Pinus elliottii
e) Eucalyptus camaldulensis
f) Acacia auriculifornis
g) Eucalyptus torrelliana
h) Casuarina equisetifolia
i) Acacia mangium

30% of sub-dominating species

a) Cinnamomum camphora
b) Bauhinia variegata
c) Sapium Discolor
d) Sapium sabeiferum
e) Schefflera octophylla
f) Sterculia lanceolata
g) Mallotus paniculatus
h) Leucaena leucocephala

30% of shrub species (understory species)

a) Rhaphiolepis indica
b) Melastoma sanguineum
c) Ligustrum sinensis
d) Gordonia axillaris
e) Syzygium buxifolium
f) Nerium indicum
g) Thevetia peruviana

5.3 Landscaping Treatment

In order to attenuate and if possible shield the direct views of the substation especially to those residing close to it, i.e., the residents in Areas 7 and 8, an extensive landscaping and replanting programme will be carried out upon completion of the building works.

The proposed landscaping layout is shown in Appendix 10. The areas around the substation will be replanted with various species of plants in order to reproduce a natural woodland effect which will integrate with the surrounding vegetation.

Three type of mixes are proposed to be used for landscaping the area and these are to be established as shown in the landscaping layout - Appendix 10.

The proposed planting schedule is as follows :-

5.3.1 Plant Schedule - Slope Planting

Trees	Size (mm)	Spacing
Acacia confusa	2750-4000	Standard size trees
Cassia surattensis	2750-4000	planted in random mix
Macaranga tanarius	2750-4000	in locations indicated
Melaleuca leucadendron	2750-4000	on planting plan
Bamboos		
Bambusa textilis (B.T.)	1500-2000	As shown
Bambusa vulgaris (B.V.)	1500-2000	As shown

Whips (Mix A)		No/Grid	%/GRID
Tree Species			
Acacia confusa	600-1500	4	16
Delonix regia	600-1500	3	12
Melaleuca leucadendron	600-1500	3	12
Pinus elliotii	600-1500	3	12
Sapium discolor	600-1500	3	12
			64
Shrub Species			
Gordonia axillaris	500 x 500	3	12
Melastoma candidum	300 x 300	3	12
Nerium indicum	750 x 500	3	12
			36

Whips (Mix B)		No/Grid	%/Grid
Tree Species			
Casuarina equisetifolia	600-1500	4	16
Ficus microcarpa	600-1500	3	12
Liquidambar formosana	600-1500	3	12
Schefflera octophylla	600-1500	3	12
Tristania conferta	600-1500	3	12
			64
Shrub Species			
Duranta repens	500 x 500	3	12
Ligustrum sinense	500 x 500	3	12
Thevetia peruviana	750 x 500	3	12
			36

Whips (Mix C - Edge planting)		No/Grid	%/Grid
Tree Species			
Baubinia blakeana	600-1500	2	4
Cassia surattensis	600-1500	2	4
Delconix regia	600-1500	2	4
			12
Shrub Species			
Allannoda cathartica	500 x 500	2	4
Clerodendron fragrans	500 x 500	2	4
Gordonia axillaris	500 x 500	2	4
Jasminum mesnyi	500 x 500	2	4
Russelia equisetiformis	400 x 400	2	4
Tecoma stans	500 x 500	1	2
Tecomaria capensis	500 x 500	2	4
Thevetia peruviana	750 x 500	1	2
			28
Ground Cover Species			
Asparagus sprengeri	300 x 300	15	30
Lantana montevidensis	300 x 300	15	30
			60

5.3.2 Landscaping Plan

A landscaping plan with maintenance schedules will be submitted to the relevant authorities for approval prior to the commencement of building works. It is envisaged that planting would be started when the substation civil works are complete.

The random and mixed planting will create a natural woodland effect which will blend in with the existing woodland features of the area. The indigenous and the known introduced species will be able to thrive in the location. Once established, they will create a screening effect and reduce the visual impact of the 400kV substation. Instead of a stark and clinical building which is usually associated with an industrial facility, the substation will appear to the residents in the area as a business centre surrounded by trees and bushes.

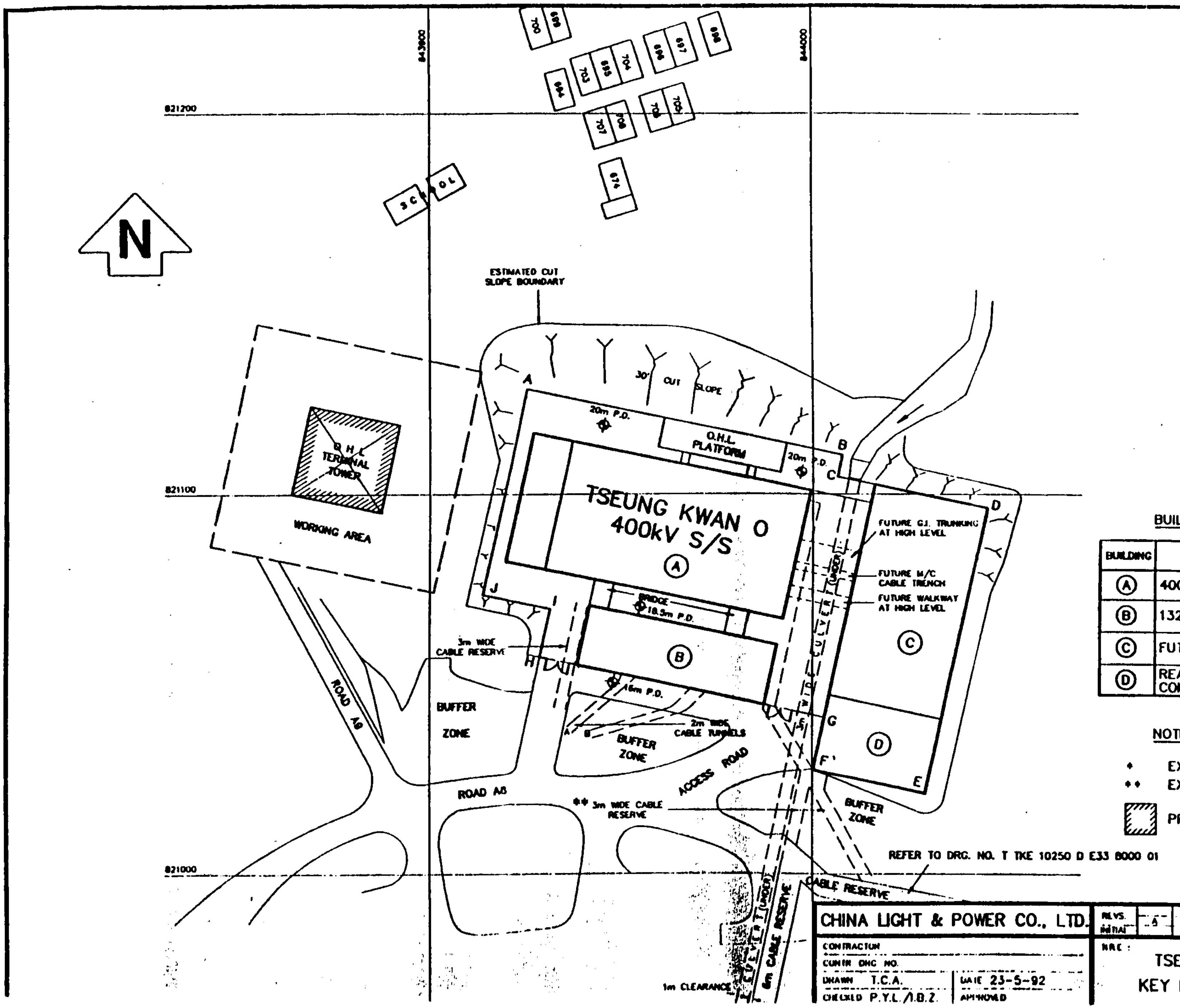
6. CONCLUSIONS

It has been shown that there will be virtually no air or water pollution arising from the operation of the substation. With the inclusion of noise control measures into the equipment and building designs, it has been concluded in the Noise Impact Assessment previously submitted to the Environmental Protection Department that noise from the substation would not be a source of disturbance to the existing or future planned development in the area.

It is recognised that the substation will be a source of obstruction to the existing views especially of the future low rise village development in areas 7 and 8 to the south of the substation. However direct view of the substation will be attenuated by the extensive planting of trees and shrubs and the landscaping treatment of the surrounding area. Measures to mitigate the visual impact including architectural and landscaping considerations will be taken into account in the detailed design stage of the substation.

The development of the Tseung Kwan O 400kV Substation must be viewed in the context of the already expanding urbanisation of the area which in itself is completely changing the environment. It is believed that the combined effects of the architectural design of the substation buildings and skillful landscaping treatment will ensure that any intrusive elements of the development are minimised.

APPENDIX 1



SITE DIMENSIONS

SIDE	DISTANCE IN METRES
AB	84
BC	6
CD	40
DE	77
EF	30
FG	14
GH	76
HI	13
IJ	18
JA	56

BUILDING HEIGHT

BUILDING	DESCRIPTION	HEIGHT (IN METRES)	GROUND LEVEL AT P.D.(IN METERS)
A	400kV BUILDING	30 *	20
B	132kV BUILDING	19.5*	18.5
C	FUTURE BLOCK	20	20
D	REACTIVE COMPENSATION BLOCK	10	20

NOTE :

* EXCLUDE WATER TANK OR MICROWAVE TOWER

** EXACT ALIGNMENT TO BE DETERMINED LATER

PRELIMINARY POSITION OF TERMINAL TOWER

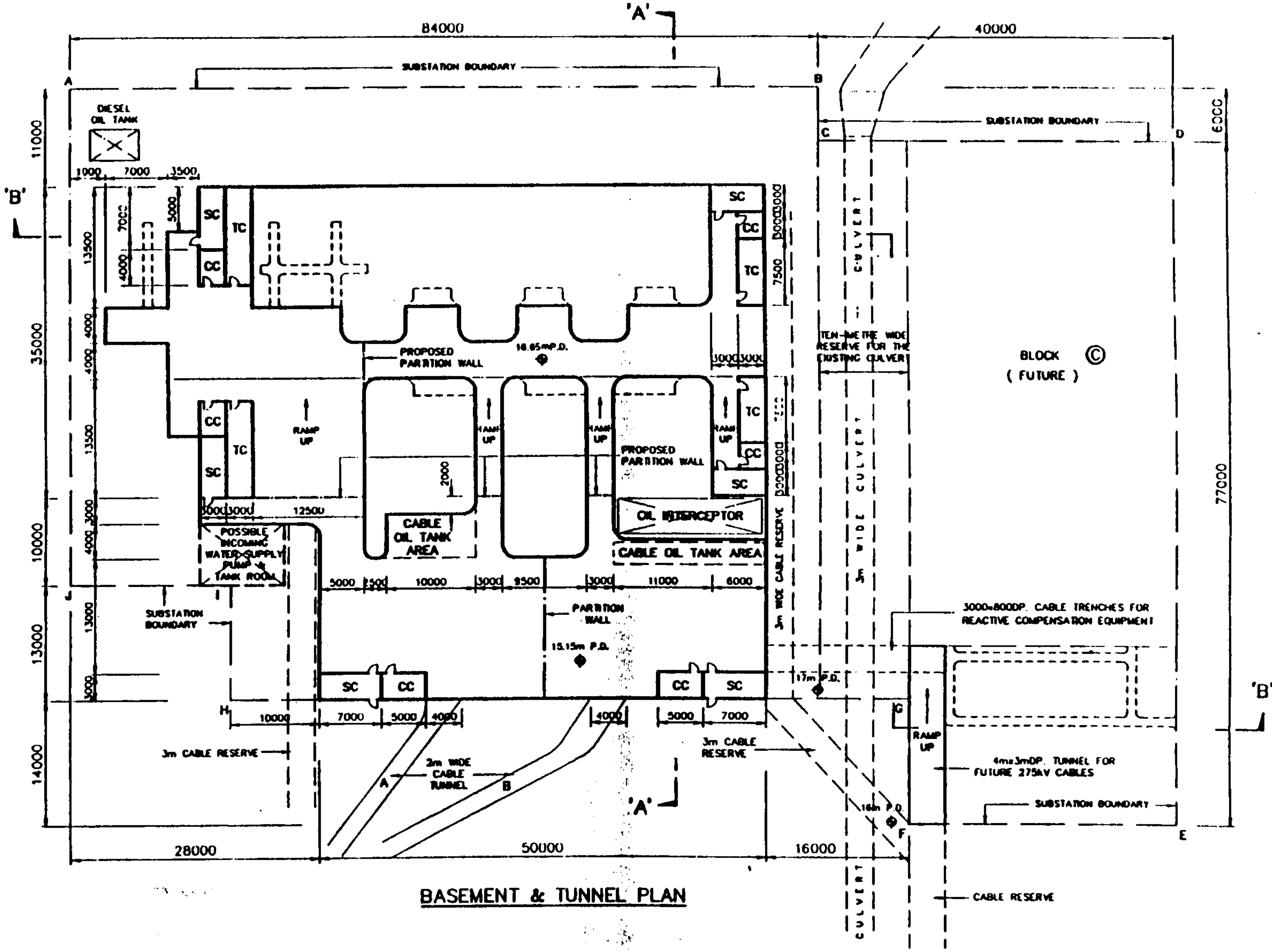
CHINA LIGHT & POWER CO., LTD.

CONTRACTOR
CONTR DWG NO.
DRAWN T.C.A.
CHECKED P.Y.L./A.B.Z.
DATE 23-5-92
APPROVED

REVS. INITIAL A B C D E F G H J K L

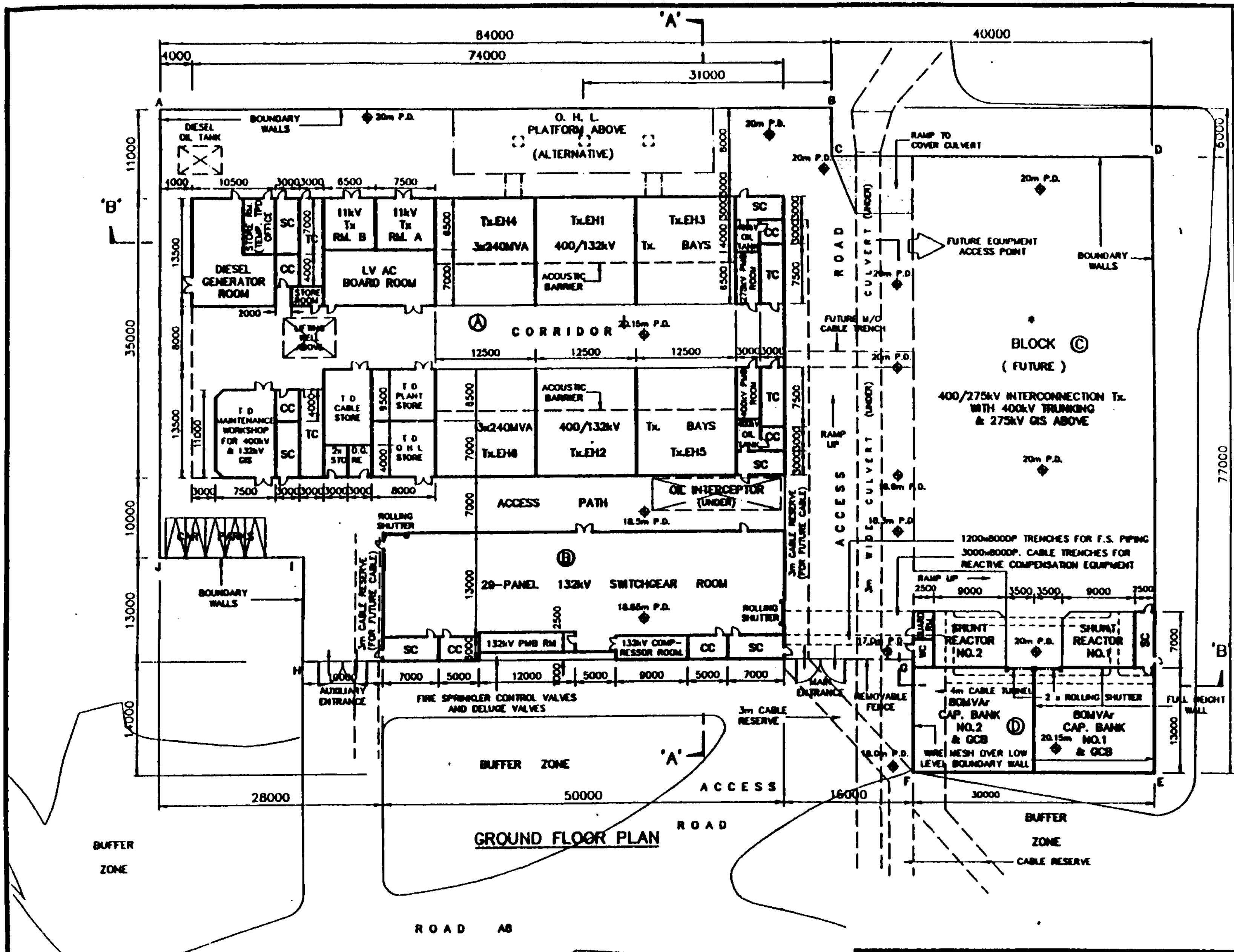
TITLE: TSEUNG KWAN O 400kV SUBSTATION KEY PLAN WITH SUBSTATION BOUNDARY

APPENDIX 2



BASEMENT & TUNNEL PLAN

CHINA LIGHT & POWER CO., LTD.		TITLE :
CONTRACTOR		TSEUNG KWAN O 400kV SUBSTATION OUTLINE PLAN
CONTR. DRG. NO.		
DRAWN T.C.A.	DATE 23-5-91	
CHECKED S.W.I./P.Y.L.	APPROVED H.L.Y.	
SCALE 1:500		



KEY PLAN (SCALE 1:5000)

HEIGHT ABOVE GROUND FLOOR LEVEL OF THE BUILDING

Ⓐ 30 m
Ⓑ 19.5 m
Ⓒ 20 m
Ⓓ 10 m

LEGEND :

CC MULTICORE CABLE CHASE
DG DANGEROUS GOODS
SC STAIRCASE
TC GI TRUNKING CHASE / POWER CABLE CHASE
WC LAVATORY

NOTE :

1. * FUTURE BLOCK TO BE CONSTRUCTED AT A LATER STAGE.
2. THIS DRAWING TO BE READ IN CONJUNCTION WITH DRG. NO. T TKE 10250 D E33 3008 01
3. APPROPRIATE LIFTING FACILITIES PROVIDED FOR TD WORKSHOP / STORES.

B GENERAL REVISION

CHINA LIGHT & POWER CO., LTD.

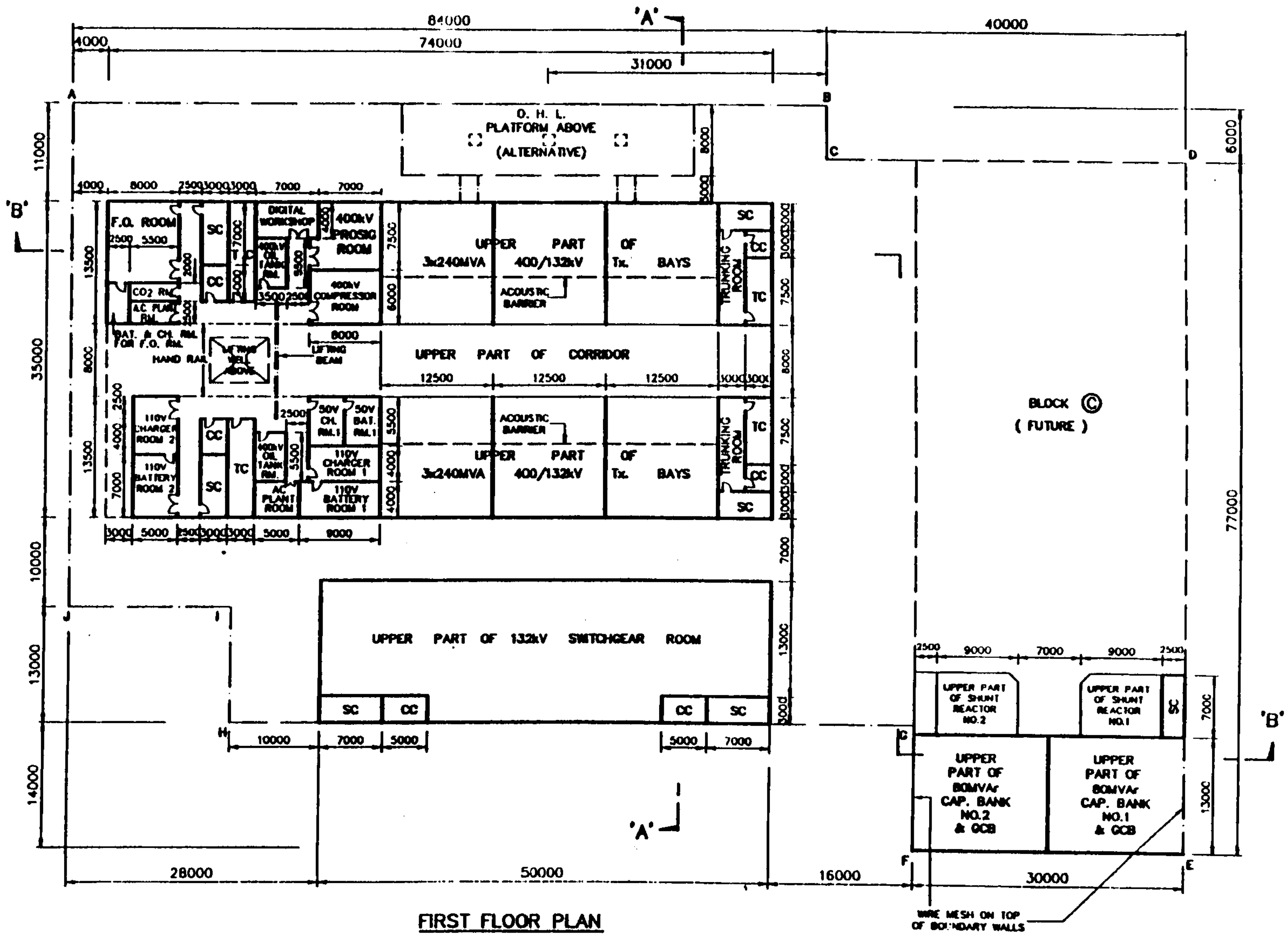
CONTRACTOR
CONTR. DRG. NO.
DRAWN T.C.A
CHECKED S.W.I./P.Y.L.
SCALE 1:500
DATE 23-5-91
APPROVED H.L.Y.
SHEETS IN SET 8

REVS. A B
INITIAL S.W.I. S.W.I.

TITLE :

TSEUNG KWAN O 400kV SUBSTATION OUTLINE PLAN

PROJECT NO. 04-590
CONTRACT NO.



FIRST FLOOR PLAN

B | GENERAL REVISION

CHINA LIGHT & POWER CO., LTD.

CONTRACTOR

CONTR. DWG. NO.

DRAWN T.C.A.

DATE 23-5-91

CHECKED S W T / P Y L

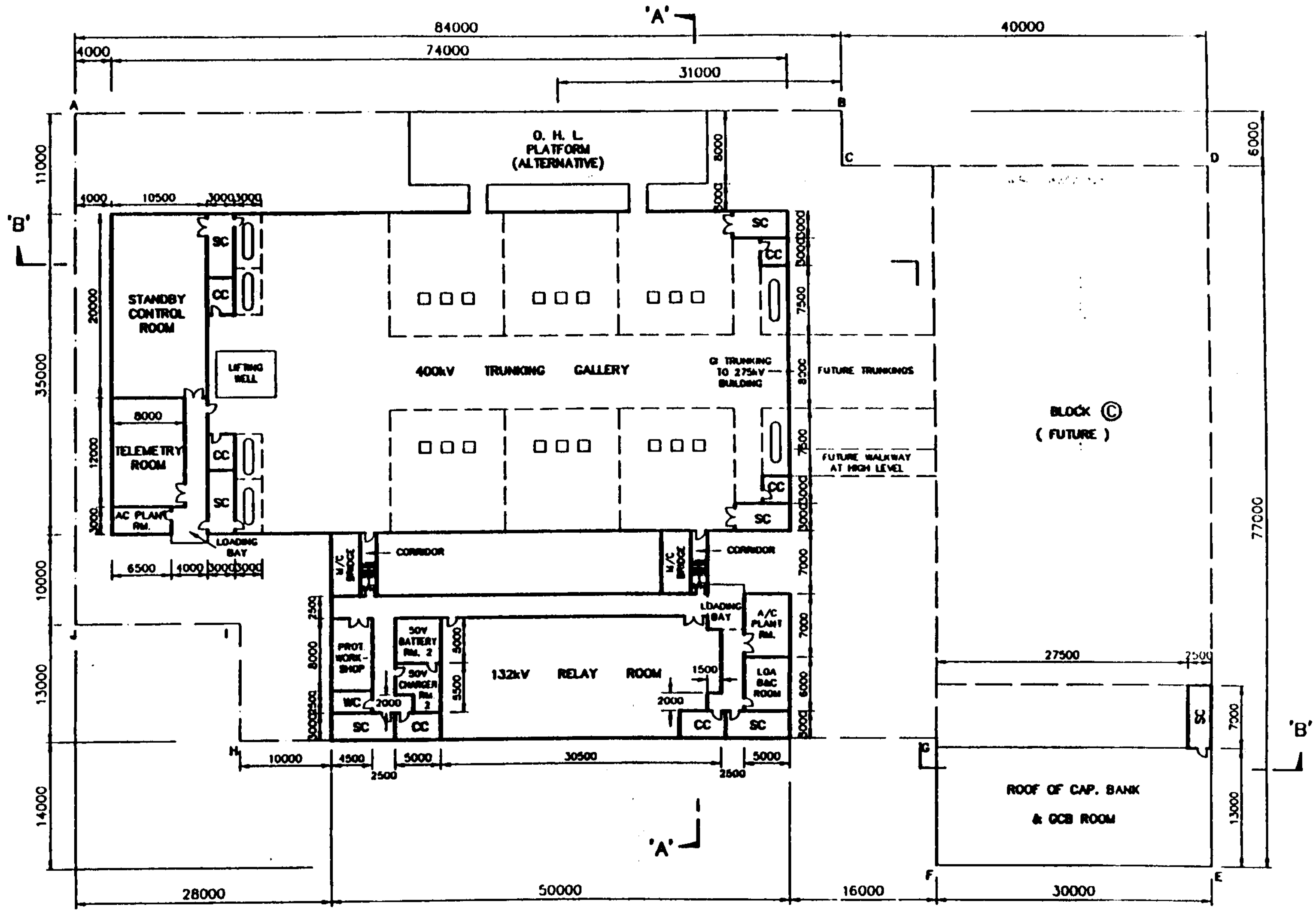
APPROVED H.L.Y

REVS. A B

INITIAL S W T S W T

TITLE :

TSEUNG KWAN O 400kV SUBSTATION
OUTLINE PLAN



TRUNKING GALLERY FLOOR PLAN

B	GENERAL REVISION
A	GENERAL REVISION

CHINA LIGHT & POWER CO., LTD.

REVS.	A	B	C	D	E	F	G	H	J	K	L
DATE	8.8.91	2.9.91									
INITIAL	S.W.T.	S.W.T.									

CONTRACTOR

CONTR. DWG. NO.

DRAWN T.C.A. DATE 23-5-91

CHECKED S.W.T./P.Y.L. APPROVED H.L.Y.

SCALE 1:500 SHEETS IN SET 8

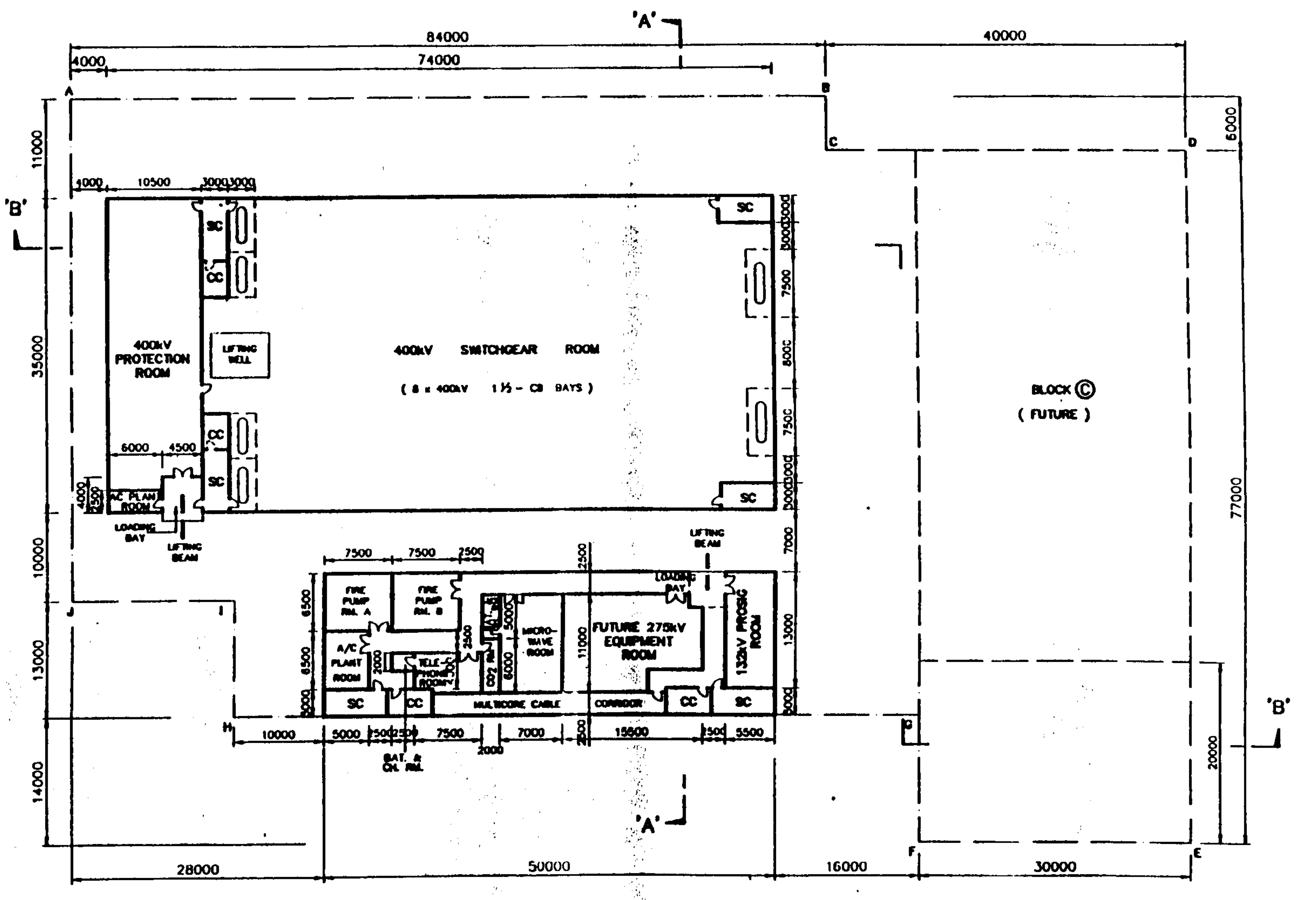
TRANSMISSION PROJECTS DEPARTMENT

TITLE: TSEUNG KWAN O 400kV SUBSTATION OUTLINE PLAN

PROJECT NO. 04-590

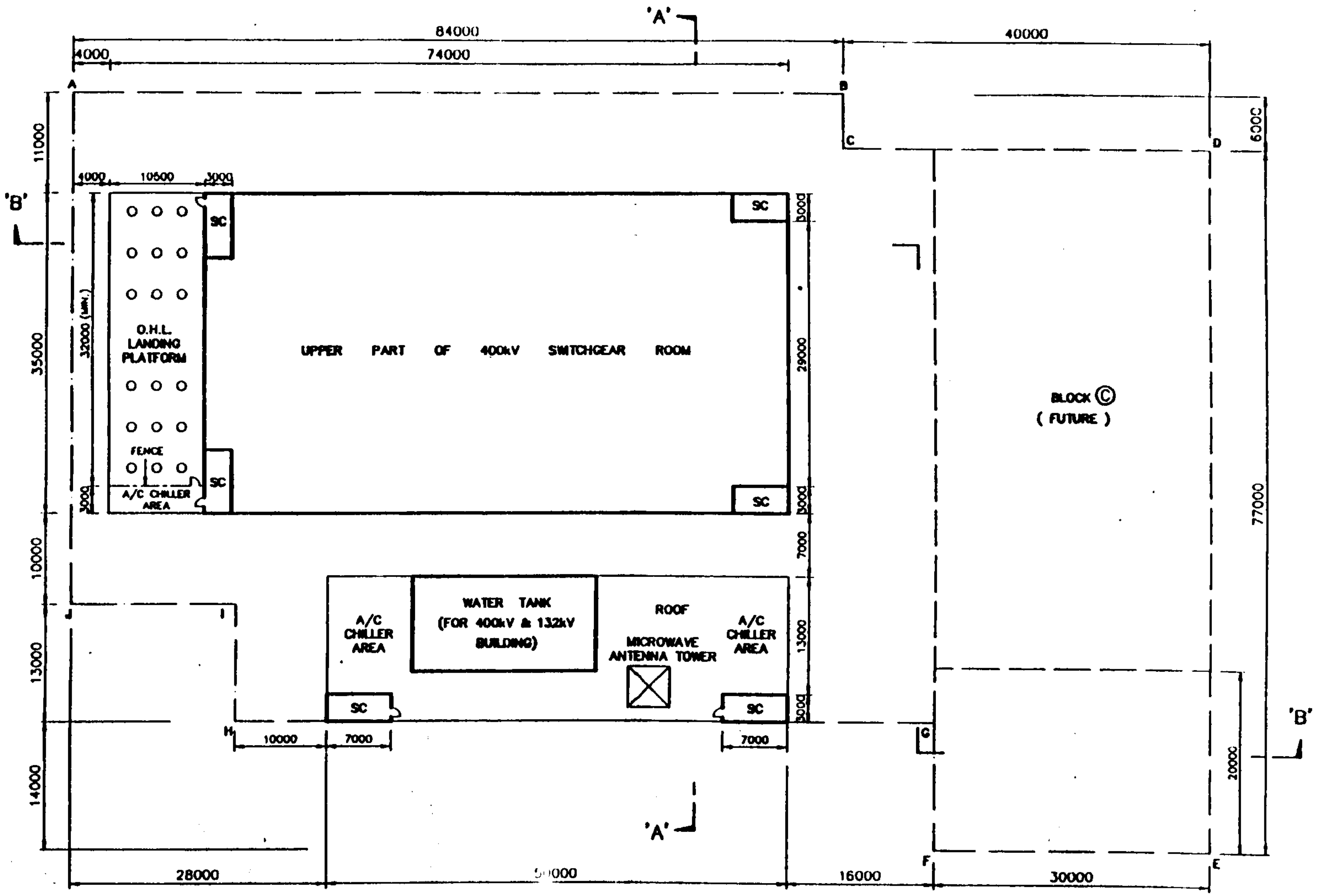
CONTRACT NO.

DRG NO.



400kV SWITCHGEAR FLOOR PLAN

CHINA LIGHT & POWER CO., LTD.		REVS. / INITIAL	8.8.91 A S.W.T.	2.9.91 B S.W.T.	C	D	E	F	G	H	J	K	L
CONTRACTOR		TITLE : TSEUNG KWAN O 400kV SUBSTATION OUTLINE PLAN											
CONTR. DRG. NO.													
DRAWN T.C.A.	DATE 23-5-91												
CHECKED S.W.T./P.Y.L.	APPROVED H.L.Y.												



UPPER PART OF 400kV SWITCHGEAR FLOOR PLAN

B	GENERAL REVISION
A	GENERAL REVISION

CHINA LIGHT & POWER CO., LTD.

CONTRACTOR	
CONTR. DRG. NO	
DRAWN T.C.A.	DATE 23-5-91
CHECKED S.W.T./P.Y.L.	APPROVED H.L.Y.
SCALE 1:500	SHEETS IN SET 8

TRANSMISSION PROJECTS DEPARTMENT

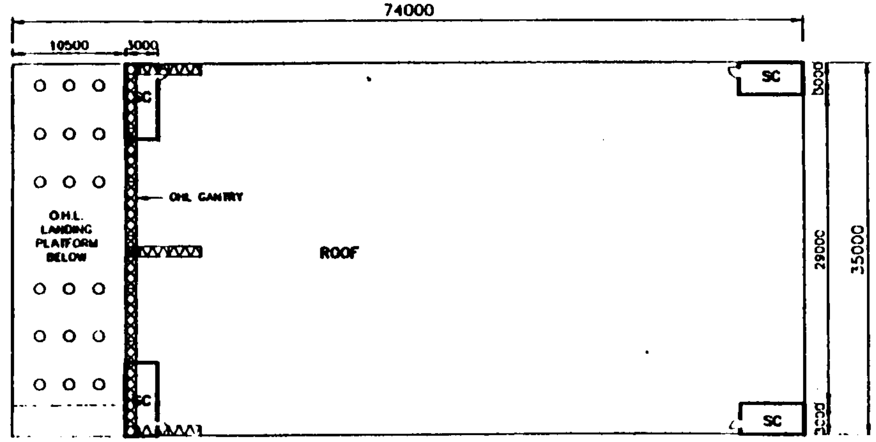
REVS	8.8.91 A	2.9.91 B	C	D	E	F	G	H	J	K	L
INITIAL	S.W.T.	S.W.T.									

TITLE :

TSEUNG KWAN O 400kV SUBSTATION
OUTLINE PLAN

PROJECT NO 04-590 | CONTRACT NO

DRG NO



ROOF PLAN

B	GENERAL REVISION
A	GENERAL REVISION

CHINA LIGHT & POWER CO., LTD.

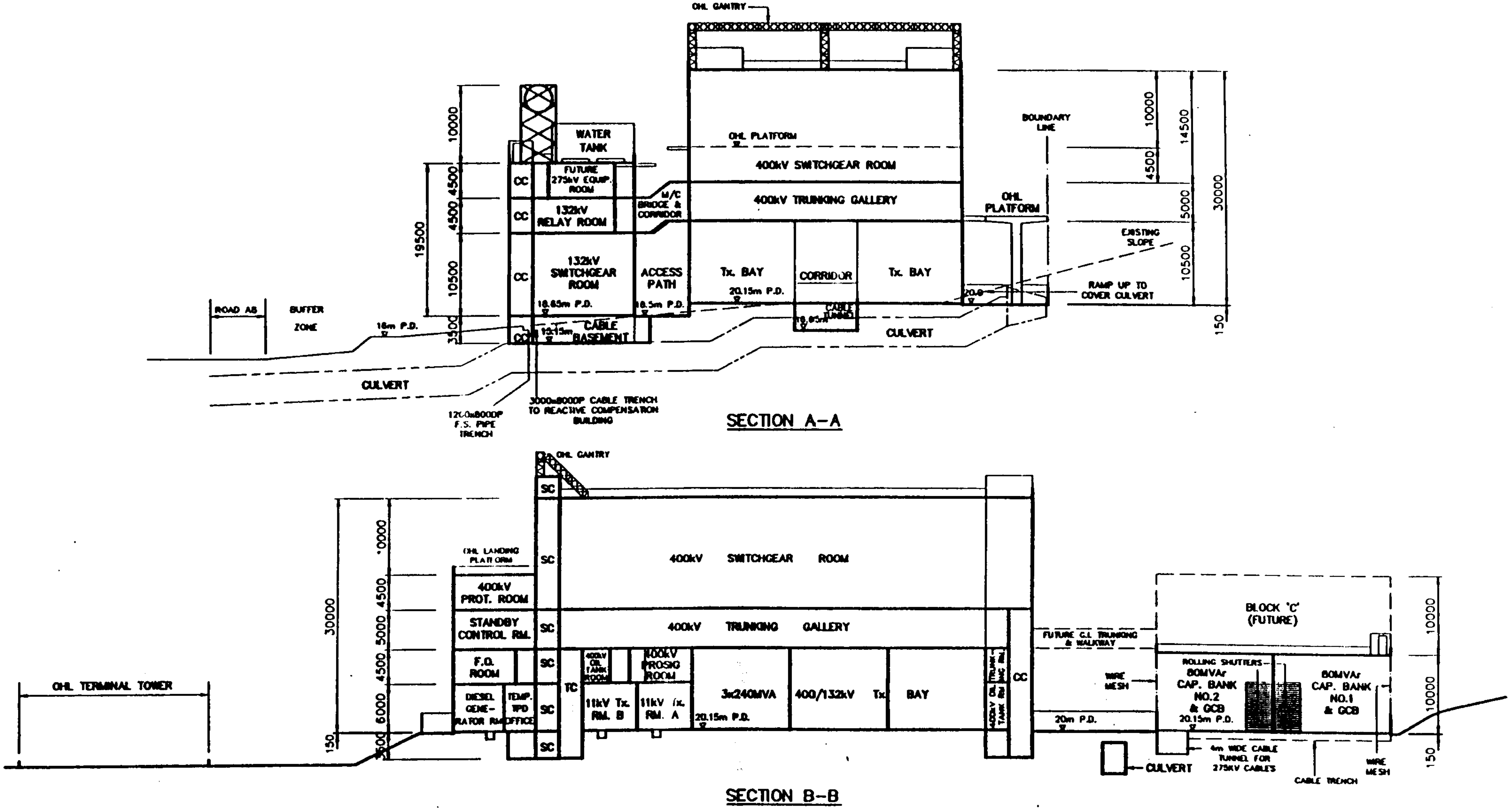
REVS	8.8.91 A	2.9.91 B
INITIAL	S.W.T.	S.W.T.

CONTRACTOR
CONTR. DRG. NO.
DRAWN T.C.A. DATE 23-5-91
CHECKED S.W.T./P.Y.L. APPROVED H.L.Y.
SCALE 1:500 SHEETS IN SET 8

TITLE
TSEUNG KWAN O 400kV SUBSTATION
OUTLINE PLAN

PROJECT NO. 04-590

TRANSMISSION PROJECTS DEPARTMENT



B	GENERAL REVISION		
A	GENERAL REVISION		

CHINA LIGHT & POWER CO., LTD.

CONTRACTOR			
CONTR. DRG. NO.			
DRAWN	T.C.A.	DATE	23-5-91
CHECKED	S.W.T./P.Y.L.	APPROVED	H.L.Y.
SCALE	1:500	SHEETS IN SET	8

TRANSMISSION PROJECTS DEPARTMENT

REVS.	A	B	C	D	E	F	G	H	J	K	L
DATE	8.8.91	2.9.91									
INITIAL	SWT	SWT									

TITLE : TSEUNG KWAN O 400kV SUBSTATION OUTLINE PLAN

PROJECT NO 04-590 | CONTRACT NO

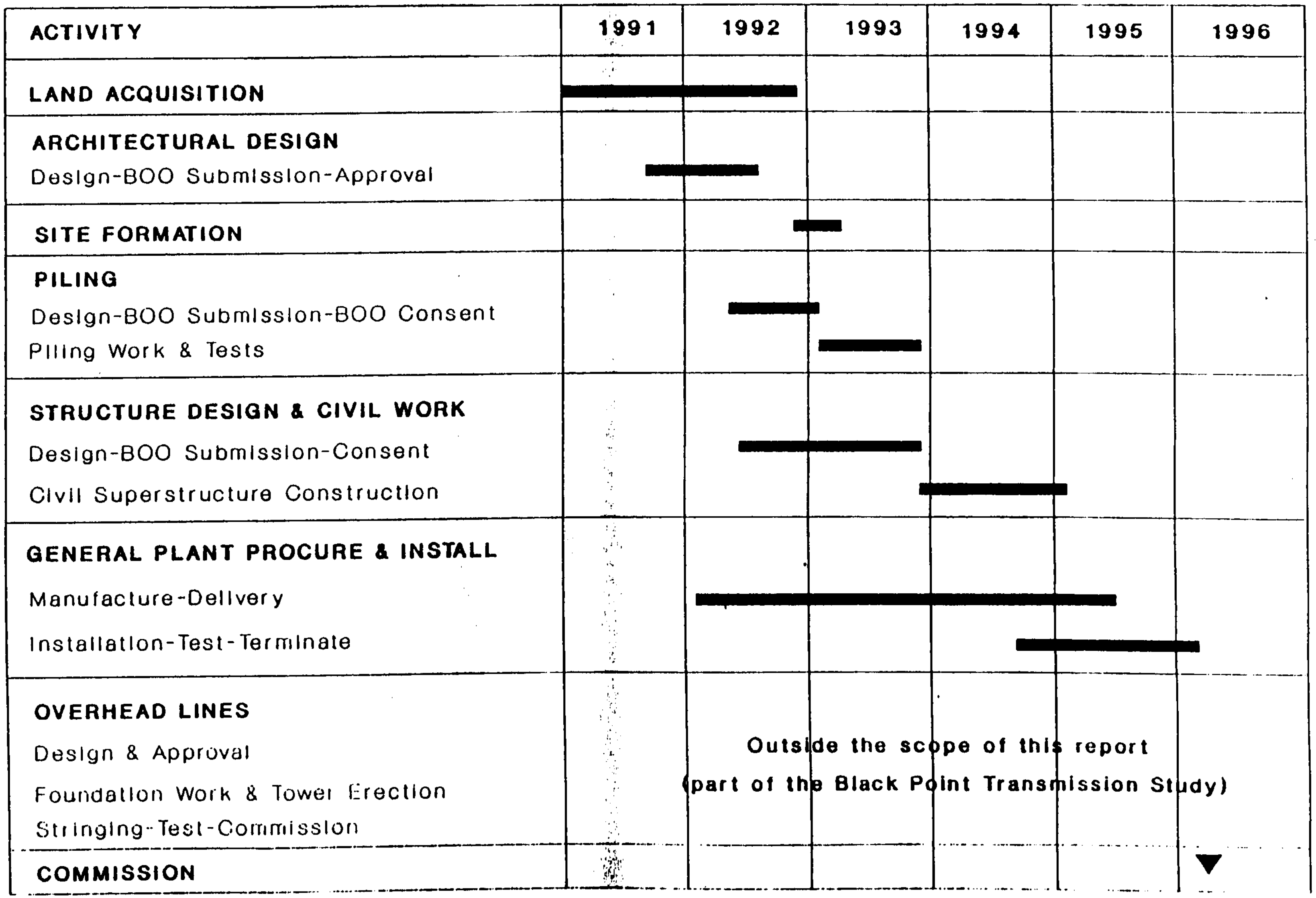
SU | DRG.NO T/TKE/10250/0/1331/3011/08/B/A

APPENDIX 3

CONSTRUCTION PROGRAMME

TSEUNG KWAN O 400 kV SUBSTATION

30/04/92



Electric and Magnetic Field Measurements Inside Substations

The following are extracts from a report entitled "Electric and Magnetic Field Measurements Under High Voltage Overhead Lines and inside Substations". The measurements were taken by the Scientific and Technical Services Department of CLP. Only those items relevant to substations are reproduced here for reference.

Measurements and Findings

With a portable instrument which responds only to the AC electric and magnetic fields, on-site tests were carried out on the selected samples of overhead lines, switchboards, underground cables, and household appliances. The test results for switchboards are shown below :-

Metalclad Switchboards

Substation	System Voltage	Current of the panel where max. magnetic flux density was measured	Electric Field Strength (Max.)	Magnetic Flux Density (Max.)
Tze Wan Shan *	400kV	700A	0.01kV/m	0.059mT
Tuen Mun	132kV	500A	0.01kV/m	0.047mT
Tuen Mun	33kV	500A	0.01kV/m	0.052mT
Tuen Mun	11kV	920A	0.01kV/m	0.068mT

Results

One sample on each of the 400kV, 132kV, 33kV and 11kV metalclad switchboards was measured. The measurements were taken around the switchboard, at positions of 1 metre above ground level and 0.5 metre away from the panels.

The screening effect of the earthed metal enclosure of the switchboard has reduced the electric field strength to a negligible value of less than 0.01kV/m. The highest magnetic flux density around the switchboards was 0.068mT, which was measured at the panel carrying the largest load current of 920A.

Conclusion

1. Owing to the screening effect, plant equipment which has earthed metal enclosure would limit the "spread" of electric field.

2. The magnetic field produced by a conductor is basically current dependent, and similar to the electric field, it diminishes rapidly over distance. Ferrous material and other current carrying conductors nearby could affect its field pattern and intensity.

3. The electric field strength and magnetic flux density measured under overhead lines, aroung switchboards and over underground cables of 132kV systems and below were within the IRPA exposure limits for the general public.

APPENDIX 4

Table 1

Theoretical Maxima of Fields Under CLP Overhead Lines at the Point of Minimum Ground Clearance

Type of Overhead Line	Max. Electric Field Strength kV/m	Max. Magnetic Field Strength mT
132kV Single Circuit Pole Line	1.8	0.01
132kV Double Circuit Tower Line	2.8	0.02
400kV Double Circuit Tower Line (Across Village Areas)	3.4	0.02
400kV Double Circuit Tower Line (Across Undeveloped Land)	10.0	0.03

Note 1 : These field strengths only occur in a very small zone under the part of the span nearest the ground. The average value under the whole span will be typically half the maximum figure.

Note 2 : The 400kV transmission lines are designed with a 100% standby capacity. In an emergency situation the indicated electric field strength could be exceeded for a short time by about 15% and the magnetic field by 100%.

Table 2

Calculated Fields At Locations Where The Public Have Access Or Might Be Expected to Spend Time (All Locations Under the Proposed New 400kV Overhead Lines)

Location (Type of Use)	Ground Clearance m	Maximum Electric Field Strength kV/m	Maximum Magnetic Field Strength mT
YS2C - YS3 Boy Scouts Assn.	27.2	Below 1.5	Below 0.01
TD13A - TD14 Miniature Car Racing Ground	38.8	Below 1.0	Below 0.01
TD24 - TD25 Kindergarden	25 - 26	Below 1.5	Below 0.01
YL45 - YL46 Road/Parking Area	54.4	Below 1.0	Below 0.01
YL55 - YL56 Playing Field	30.0	Below 1.5	Below 0.01

Key YS - Yuen Long - Border Line
TD - Tai Po - Border Line
YL - Yuen Long - Lai Chi Kok Line

a/jb:at(0134a/p.35-36)

CHINA LIGHT & POWER COMPANY, LIMITED
中華電力有限公司
Transmission Projects Department
6/F., SHAM SHUI PO CENTRE,
215 FUK WAH STREET, SHAM SHUI PO,
KOWLOON, HONG KONG.
telephone 3-606222 telex 39187 LIGHT HX
cables: LIGHTPOWER HONG KONG

Please address all letters to the Com...

our ref: 211-22/L.501/90/RAC/WAA/AJB your ref. 57/18/11

11th June, 1990

Director of Electrical & Mechanical Services,
Electrical & Mechanical Services Department,
98 Caroline Hill Road,
Hong Kong.

Attention : Mr. John Chan

Dear Sirs,

Limits of Exposure to 50/60 Hz
Electric and Magnetic Fields

Further to our letter of 4th May, 1990, we have now completed a sample study of how the electric and magnetic fields that could occur under our overhead lines compare with the IRPA/INIRC guideline limits. We are pleased to advise that for all normal operating conditions our designs, route selection procedures and clearance practices give rise to fields which are lower than the guideline limits. Our study has been based on the worst case situation of looking at the very small zone under the lowest point of the conductors between any two towers - this would of course be located mid-span if the route were on level ground, but, with the hilly routes that we are usually obliged to adopt, has a varying location depending on the local topography. The highest fields which could theoretically occur in this small zone are given for various voltages and circuit configurations in Table 1. For comparison, we have checked the areas under our new 400kV lines which fall in the specific category of "public open spaces" and these are listed in Table 2. It can be seen that most "real-life" situations will experience much lower fields than the theoretical maxima due to the fact that these situations almost invariably involve much greater ground clearances and often, in addition, benefit from the screening effects of surrounding structures. These factors lead us to conclude that, for the few potential locations where the public could congregate, both magnetic and electric field strengths are likely to be of an order of magnitude below those of the guidelines.

In view of the above, we have no objections to the adoption of the IRPA/INIRC guidelines, and rather than adopt selected extracts which only cover part of the land under our overhead lines, would prefer to adopt the guidelines in total so as to improve public confidence in the subject and demonstrate that CLP is prepared to follow the international concensus of opinion.

2/.....

CHINA LIGHT & POWER COMPANY, LIMITED

Our Ref. : 211-22/L.501/90/RAC/WAA/AJB

Date : 11th June, 1990

We wish, however, to place on record that our agreement to adoption of the guidelines is intended to improve public confidence until such time as the effects of fields in general are better understood. We do not consider, from the evidence produced to date, that there is anything to lead us to conclude that there is a health risk imposed from our electricity network and believe that it will be a considerable time before sufficient understanding of the inter-relation of fields and living organisms allows the question of whether there is any significant health hazard which warrants positive action to be answered.

It should be noted that the health effects suggested in the few adverse epidemiological studies so far completed, are based on fields occurring in typical American homes which are fed from high rating overhead distribution systems. Such distribution systems are not used in Hong Kong and hence the studies and their conclusions are not necessarily relevant to our system.

Yours faithfully,
CHINA LIGHT & POWER CO., LTD.

R.A. Carter
Project Manager - Transmission Projects

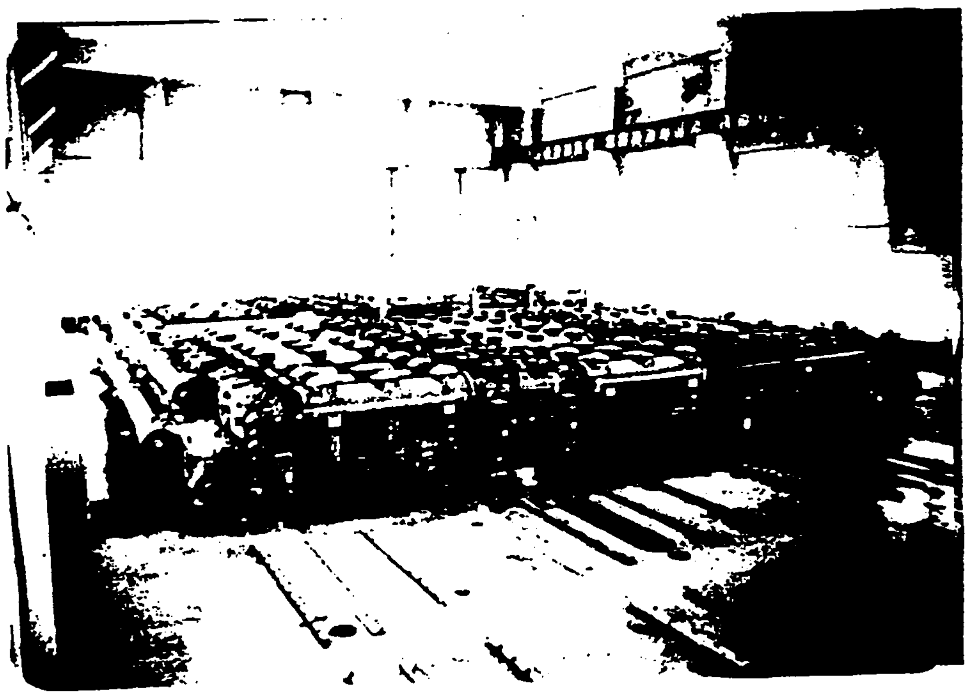
waa:ajb:at(p.33-34)

c.c. Mr. J.H. Woods
Mr. R.A. Carter
Mr. W.A. el Arculli
Mr. B. Manifold
Mr. A.J. Bielby
Mr. W.B. Hill

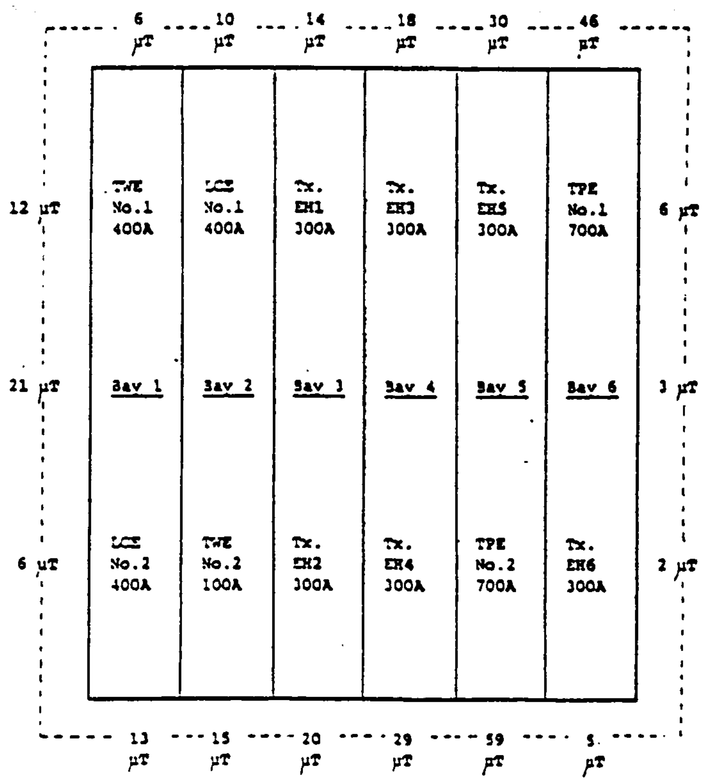
967-233-08

Typical Test Arrangement of Switchboards

1. 400kV Switchboard at Tze Wan Shan Substation



2. Field Distribution



Note :
* Measurements were taken around the switchboard, at positions 1 metre above ground level and 0.5 meter away from the panels.
* Electric Field strength around the switchboard is less than 0.01kV/m.
* Magnetic flux density values are shown above.

APPENDIX 5

Health Physics Vol. 58, No. 1 (January), pp. 113–122, 1990
Printed in the U.S.A.

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Pergamon Press plc

● *IRPA/INIRC Guidelines*

INTERIM GUIDELINES ON LIMITS OF EXPOSURE TO 50/60 Hz ELECTRIC AND MAGNETIC FIELDS

International Non-ionizing Radiation Committee
of the
International Radiation Protection Association

PREFACE

THE INTERNATIONAL Radiation Protection Association (IRPA) formed a working group on non-ionizing radiation (NIR) in 1974, which examined the problems arising in the field of protection against the different types of non-ionizing radiation. At the 1977 IRPA Congress in Paris, this working group became the International Non-Ionizing Radiation Committee (IRPA/INIRC).

The IRPA/INIRC, in cooperation with the Environmental Health Division of the World Health Organization (WHO), has undertaken responsibility for the development of health criteria documents on NIR. These form part of the WHO Environmental Health Criteria Programme, which is sponsored by the United Nations Environment Programme (UNEP). The documents include an overview of the physical characteristics, measurement and instrumentation, sources and applications of NIR, a thorough review of the scientific literature on biological effects, and evaluations of the health risks of human exposure to NIR. These criteria then become the scientific data base for the development of exposure limits and codes of practice.

In particular, two documents, Environmental Health Criteria 35: Extremely Low Frequency (ELF) Fields (UNEP/WHO/IRPA 1984) and Environmental Health Criteria 69: Magnetic Fields (UNEP/WHO/IRPA 1987), contain a review of the biological effects reported from exposure to ELF electric and magnetic fields and, together with more recent publications, serve as the scientific rationale for these interim guidelines.

During the preparation of these guidelines, the composition of the IRPA/INIRC was as follows:

H. P. Jammet, Chairman (France)
J. H. Bernhardt (Federal Republic of Germany)
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INTRODUCTION

Just over 100 y ago, human exposure to external electric and magnetic fields was limited to those fields arising naturally. Within the past 50 y, there has been very significant growth of man-made, extremely low frequency (ELF) electromagnetic fields at frequencies of 50 and 60 Hz predominantly from electric energy generation, transmission, distribution, and use. Man-made ELF fields are now many orders of magnitude greater than the natural fields at 50 and 60 Hz.

Within all organisms are endogenous electric fields and currents that play a role in the complex mechanisms of physiological control, such as neuromuscular activity, glandular secretion, cell-membrane function and development, growth, and repair of tissue. It is not surprising that, because of the role of electric fields and currents in so many basic physiological processes (Grandolfo et al. 1985), questions arise concerning possible effects of artificially produced fields on biological systems. With advances in technology and the ever greater need for electric energy, human exposure to 50/60 Hz electric and mag-

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netic fields has increased to the point that valid questions are raised concerning safe limits of such exposure.

Public concern is growing, and in many countries regulatory and advisory agencies have been requested to evaluate possible adverse effects of ELF electromagnetic fields on human health (Grandolfo and Vecchia 1989). From a review of the scientific literature, it is apparent that gaps exist in our knowledge, and more data need to be collected to answer unresolved questions concerning biological effects of exposure to these fields. On the other hand, analysis of the existing literature does not provide evidence that exposure at present day levels has a public health impact which would require corrective action. In several countries there is an ongoing controversy between proponents of restrictive protective measures and advocates of technological growth leading to an increase in exposure levels. It thus appeared that there was a need for guidelines on exposure limits based on an objective analysis of currently available knowledge. A detailed discussion of potential adverse effects can be found in the literature (Ahlbom et al. 1987; UNEP/WHO/IRPA 1984; UNEP/WHO/IRPA 1987), and a summary is presented in the Rationale for Exposure Limits section.

A first draft of these interim guidelines was distributed to the Associate Societies of IRPA and to various institutions and individual scientists for comments. Many helpful comments and criticisms were obtained and are gratefully acknowledged.

The Committee recognizes that when exposure limits are established, various value judgments have to be made. The validity of scientific reports must be considered, and extrapolation from animal experiments to effects on humans has to be made. A cost-benefit analysis, taking into account national public health priorities and considerations of economic impact and social issues, may be necessary to derive limits suited to the conditions prevailing in different countries.

The rationale for these interim guidelines is provided in the Rationale for Exposure Limits section. Measures used to protect workers and the general public from excessive or unnecessary exposure to 50/60 Hz fields are given in the section Protective Measures.

PURPOSE AND SCOPE

These guidelines apply to human exposure to electric and magnetic fields at frequencies of 50 or 60 Hz. The guidelines do not apply to deliberate exposure of patients undergoing medical diagnosis or treatment.

QUANTITIES AND UNITS

Transmission lines and electrical devices generate 50/60 Hz electric and magnetic fields in their vicinity. The electric and magnetic fields must be considered separately because at the very long wavelengths (thousands of kilometers in free space or air) corresponding to these frequencies, measurements are made in the near field of the source where the electric and magnetic fields are not in a constant relationship. Biological systems are extremely small compared to these wavelengths so the electric and magnetic fields interact (couple) separately with the system.

The electric field created in the vicinity of a charged conductor is a vector quantified by the electric field strength, E. This vector is the force exerted by an electric field on a unit charge and is measured in volts per meter ($V\ m^{-1}$). The E-vector either oscillates along a fixed axis (single-phase source) or rotates in a plane and describes an ellipse (three-phase source). Because the electric field at or close to the surface of an object in the field is generally strongly perturbed, the value of the "unperturbed electric field" (i.e., the field that would exist if all objects were removed) is used to characterize exposure conditions.

The magnetic field is a vector quantity. As in the case of electric fields, single-phase and three-phase fields can be defined whose vector properties are the same as those previously described for the E-field. The magnetic field strength, H, is the axial vector whose curl (rotation) equals the current density vector, including the displacement current, and is expressed in amperes per meter ($A\ m^{-1}$). The magnetic flux density, B, also known as the magnetic induction or simply the B-field, is accepted, however, as the most relevant quantity for expressing magnetic fields associated with biological effects. The magnetic flux density is defined in terms of the force exerted on a charge moving in the field and has the unit tesla (T). One tesla is equal to $1\ V\ s\ m^{-2}$ or 1 weber per square meter ($Wb\ m^{-2}$). An important distinction between B- and H-fields becomes apparent only in a medium which has a net polarization of magnetic dipoles. In free space, and for practical purposes in biological tissues, B and H are proportional. The ratio B:H is the magnetic permeability of free space, $\mu_0 = 4\pi\ 10^{-7}\ H\ m^{-1}$, and it is expressed in henrys per meter ($1\ H\ m^{-1} = 1\ Wb\ A^{-1}\ m^{-1}$).

The E-, B-, and H-fields can be described each as having time-varying sinusoidal components along three orthogonal axes. The effective field strength is the root of the sum of these three mean squared (temporal mean square) mutually orthogonal components.

In this document, exposure limits for the magnetic field are given in terms of the root mean square (rms) magnetic flux density. The corresponding values of the rms magnetic field strength can be obtained taking into account that $1\ \mu T$ corresponds to $0.7958\ A\ m^{-1}$, and $1\ A\ m^{-1}$ corresponds to $1.257\ \mu T$.

The quantities described above characterize somewhat idealized exposure conditions (fields impinging upon the surface of the body) because reference is made to the situation in which the exposed body is absent from the field. Thus, unperturbed E or H fields may be compared to radiometric quantities.

Biological effects should be related to the field on the surface of the body, as well as to the electric fields, currents, and current densities induced inside the body. The unit of electric current is the ampere (A), which is equal to an electric charge of 1 coulomb moving past a given point per second (C s^{-1}). The current density is a vector quantity whose magnitude is equal to the charge that crosses a unit surface area perpendicular to the flow of charge per unit of time. The current density is expressed in amperes per square meter (A m^{-2}). These quantities should be considered dosimetric. Considered rigorously, these quantities represent dose rates. In order to derive a meaningful dose concept, the dependence of biological effects upon the duration of exposure and the distribution of the dose rate in space and time have to be explored and taken into account.

Well-established effects, such as interactions with excitable membranes of nerve and muscle cells, show a dependence upon local E field strength or current density. As is the case with other dose-rate-dependent phenomena, thresholds for these effects can be demonstrated. These thresholds are best expressed in terms of the current density induced in the body. Thus, the criterion used for exposure limits is this induced current density. Because currents induced in the body cannot be easily measured directly, the working limits in terms of unperturbed electric field strength and magnetic flux density have been derived from the criterion value of induced current density. The values obtained were modified taking into account effects due to indirect coupling mechanisms as discussed in the rationale.

A review of quantities, units, and terminology for non-ionizing radiation protection has been previously published (IRPA/INIRC 1985).

EXPOSURE LIMITS

The basic criterion is to limit current densities induced in the head and trunk by continuous exposure to 50/60 Hz electric and magnetic fields to no more than about 10 mA m^{-2}.

Occupational

Electric field. Continuous occupational exposure during the working day should be limited to rms unperturbed electric field strengths not greater than 10 kV m^{-1}.

Short-term occupational exposure to rms electric field strengths between 10 and 30 kV m^{-1} is permitted, provided the rms electric field strength (kV m^{-1}) times the duration of exposure (hours) does not exceed 80 for the whole working day.

Magnetic field. Continuous occupational exposure during the working day should be limited to rms magnetic flux densities not greater than 0.5 mT.

Short-term occupational whole-body exposure for up to 2 h per workday should not exceed a magnetic flux density of 5 mT. When restricted to the limbs, exposures up to 25 mT can be permitted.

General public

Electric field. Members of the general public should not be exposed on a continuous basis to unperturbed rms electric field strengths exceeding 5 kV m^{-1}. This restriction applies to open spaces in which members of the general public might reasonably be expected to spend a substantial part of the day, such as recreational areas, meeting grounds, and the like. Exposure to fields between 5 and 10 kV m^{-1} should be limited to a few hours per day.

When necessary, exposures to fields in excess of 10 kV m^{-1} can be allowed for a few minutes per day, provided the induced current density does not exceed 2 mA m^{-2} and precautions are taken to prevent hazardous indirect coupling effects.

It should be noted that buildings in a 5-kV m^{-1} external field have a field strength lower by more than an order of magnitude inside the building.

Magnetic field. Members of the general public should not be exposed on a continuous basis to unperturbed rms magnetic flux densities exceeding 0.1 mT. This restriction applies to areas in which members of the general public might reasonably be expected to spend a substantial part of the day.

Exposures to magnetic flux densities between 0.1 and 1.0 mT (rms) should be limited to a few hours per day. When necessary, exposures to magnetic flux densities in excess of 1 mT should be limited to a few minutes per day.

Summary of exposure limits

A summary of the limits recommended for occupational and general public exposures to 50/60 Hz electric and magnetic fields is given in Table 1.

MEASUREMENT

Measurements of electric and magnetic fields should be performed according to the IEC and IEEE standards on measurement of electric and magnetic fields from AC power lines (International Electrotechnical Commission

Table 1. Limits of exposure to 50/60 Hz electric and magnetic fields.

Exposure characteristics	Electric field strength kV m^{-1} (rms)	Magnetic flux density mT (rms)
Occupational		
Whole working day	10	0.5
Short term	30[a]	5[b]
For limbs	—	25
General public		
Up to 24 h d^{-1} [c]	5	0.1
Few hours per day[d]	10	1

[a] The duration of exposure to fields between 10 and 30 kV m^{-1} may be calculated from the formula $t \leq 80/E$, where t is the duration in hours per work day and E is the electric field strength in kV m^{-1}.

[b] Maximum exposure duration is 2 h per work day.

[c] This restriction applies to open spaces in which members of the general public might reasonably be expected to spend a substantial part of the day, such as recreational areas, meeting grounds, and the like.

[d] These values can be exceeded for a few minutes per day provided precautions are taken to prevent indirect coupling effects.

1987; Institute of Electrical and Electronics Engineers 1987). For inhomogeneous magnetic fields, the magnetic flux density should be averaged on a loop surface of 100 cm^2.

Protective measures

The responsibilities for the protection of workers and the general public against the potentially adverse effects of exposure to 50/60 Hz electric and magnetic fields should be clearly assigned. It is recommended that the competent authorities consider the following steps:

- Development and adoption of exposure limits and the implementation of a compliance program;
- Development of technical standards to reduce the susceptibility to electromagnetic interference, e.g., for pacemakers;
- Development of standards defining zones with limited access around sources of strong electric and magnetic fields because of electromagnetic interference (e.g., for pacemakers and other implanted devices). The use of appropriate warning signs should be considered;
- Requirement of specific assignment of responsibility for the safety of workers and the public to a person at each site with high exposure potentials;
- Drafting of guidelines or codes of practice for worker safety in 50/60 Hz electromagnetic fields;
- Development of standardized measurement procedures and survey techniques;
- Requirements for the education of workers on the effects of exposure to 50/60 Hz fields and the measures and rules which are designed to protect them.

General rules on medical surveillance have been established by the International Labour Office in the ILO Convention 161 concerning Occupational Health Services (International Labour Office 1985).

CONCLUDING REMARKS

The exposure limits are based on established or predicted effects of exposure to 50/60 Hz fields. Although some epidemiological studies suggest an association between exposure to 50/60 Hz fields and cancer, others do not. Not only is this association not proven, but present data do not provide any basis for health risk assessment useful for the development of exposure limits.

Current laboratory studies are testing the hypothesis that 50/60 Hz fields may act as, or with, a cancer promoter. These studies are still exploratory in nature and have not established any human health risk from exposure to these fields.

These limits have been developed from present knowledge, but there are still areas of research where questions have been raised that need to be addressed. A major research effort to supplement our knowledge on the health consequences, if any, of long-term continuous exposure of humans to low-level 50/60 Hz fields is required.

There is an ever-increasing number of people wearing implanted cardiac pacemakers which may be sensitive to interference from electric and magnetic fields. These people may not always be adequately protected against interference at some of the above exposure limits (see subsection Cardiac Pacemakers).

These guidelines will be subjected to periodic revision and amendment with advances in knowledge.

RATIONALE FOR EXPOSURE LIMITS

General considerations

These guidelines are intended to protect the health of humans from the potentially harmful effects of exposure to electric and magnetic fields at frequencies of 50/60 Hz and are primarily based on established or predicted effects.

Population. The first step in establishing exposure limits is to define the population to be protected. Exposure limits may pertain to the general population or to particular groups within it.

A distinction is made between the exposure limits for workers and the general public for the following reasons. The occupationally exposed population consists of adults exposed under controlled conditions in the course of their duties who should be trained to be aware of potential risks and to take appropriate precautions. Occupational exposure is limited to the duration of the working day or duty shift per 24 h and the duration of the working lifetime.

The general public comprises individuals of all ages and different health status. Individuals or groups of particular susceptibility may be included in the general population. In many instances, members of the general public are not aware that exposure takes place or may be unwilling to take any risks (however slight) associated with exposure. The general public can be exposed 24 h d^{-1} and over a whole lifetime. Finally, the public cannot be expected to accept effects such as annoyance and pain due to transient discharges or hazards due to contact currents. The above considerations were the reason for adopting lower exposure limits for the general public than for the occupationally exposed population.

Coupling mechanisms. The more important mechanisms of these interactions (Tenforde and Kaune 1987; Bernhardt 1988) are as follows:

- Electric fields (50/60 Hz) induce a surface charge on an exposed body which results in currents inside the body, the magnitude of which is related to the surface charge density. Depending on the exposure conditions, size, shape, and position of the exposed body in the field, the surface charge density can vary greatly resulting in a variable and non-uniform distribution of currents inside the body.
- Magnetic fields from 50/60 Hz sources also act on humans by inducing electric fields and currents inside the body.
- Electric charges induced in a conducting object (e.g., an automobile) exposed to a 50/60 Hz electric field

may cause current to pass through a human in contact with it.

• Magnetic field coupling to a conductor (for example, a wire fence) causes 50/60 Hz electric currents to pass through the body of a person in contact with it.

• Transient discharges (often called sparks) can occur when people and metal objects exposed to a strong electric field come into sufficiently close proximity.

• Electric or magnetic fields (50/60 Hz) may interfere with implanted medical devices (e.g., unipolar cardiac pacemakers) and cause malfunction of the device.

The first two interactions listed above are examples of direct coupling between living organisms and 50/60 Hz fields. The latter four interactions are examples of indirect coupling mechanisms because they can occur only when the exposed organism is in the vicinity of other bodies. These bodies can include other humans or animals, and objects such as automobiles, fences, or implanted devices.

Criterion for limiting exposure

The limits recommended in these guidelines were developed primarily on established or predicted immediate health effects produced by currents induced in the body by external electric and magnetic fields. These limits correspond to induced current densities that are generally at or slightly above those normally occurring in the body (up to about 10 mA m^{-2}).

An unperturbed electric field strength of 10 kV m^{-1} induces rms current densities of less than 4 mA m^{-2} when averaged over the head or trunk region (Bernhardt 1985; Kaune and Forsythe 1985). However, peak current densities in the same regions would exceed 4 mA m^{-2} (Kaune and Forsythe 1985; Dimbylow 1987) depending on the size, posture, or orientation of the person in the electric field.

Assuming a 10-cm radius loop of tissue of conductivity 0.2 S m^{-1}, a magnetic flux density of 0.5 mT at 50/60 Hz would induce an rms current density of about 1 mA m^{-2} at the periphery of the loop.

The following statements can be made with respect to induced current density ranges and biological effects resulting from whole-body exposure to 50/60 Hz fields (UNEP/WHO/IRPA 1987):

a) Between 1 and 10 mA m^{-2}: minor biological effects have been reported;

b) Between 10 and 100 mA m^{-2}: there are well-established effects, including visual and nervous system effects;

c) Between 100 and 1000 mA m^{-2}: stimulation of excitable tissue is observed, and there are possible health hazards;

d) Above 1000 mA m^{-2}: extra systoles and ventricular fibrillation can occur (acute health hazards).

Endogenous current densities in the body are typically up to about 10 mA m^{-2}, although they can be much higher during certain functions. The Committee felt that, to be conservative, current densities induced by external electric or magnetic fields should not significantly exceed this value. Thus, limits for continuous human exposure to electric and magnetic fields were determined using this criterion.

Safety factors in health protection standards do not guarantee safety but represent an attempt to compensate for unknowns and uncertainties. Readers are referred to the Environmental Protection Agency (1986) for a description of the use of safety factors in the derivation of exposure limits.

Rationale for limits on electric field exposures

From a review of laboratory and human studies, the conclusions below were drawn by a joint WHO/IRPA Task Group studying health effects of ELF electric fields (UNEP/WHO/IRPA 1984). The guidelines are essentially based on the following WHO/IRPA conclusions and on more recent reports:

a) Animal experimentation indicates that exposure to strong ELF electric fields can alter cellular, physiological, and behavioral events. Although it is not possible to extrapolate these findings to human beings at this time, these studies serve as a warning that unnecessary exposure to strong electric fields should be avoided.

b) Adverse human health effects from exposure to ELF electric fields at strengths normally encountered in the environment or the workplace have not been established.

c) The threshold field strength for some human beings to feel spark discharges in electric fields is about 3 kV m^{-1}, and to perceive the field is between 2–10 kV m^{-1}. There are no scientific data at this time that suggest that perception of a field per se produces a pathological effect.

d) Although there are limitations in the epidemiological studies that suggest an increased incidence of cancer among children and adults exposed to 50/60 Hz fields, the data cannot be dismissed. Additional study will be required before these data can serve as a basis for risk assessment.

e) It is not possible from present knowledge to make a definitive statement about the safety or hazard associated with long-term exposure to sinusoidal electric fields in the range of 1 to 10 kV m^{-1}. In the absence of specific evidence of particular risks or disease syndromes associated with such exposure, and in view of experimental findings on the biological effects of exposure, it would be prudent to limit exposure, particularly for members of the general population.

Basis for extrapolation of experimental results to man. External electric fields induce electric currents within biological systems. The magnitude of the induced currents depends on a number of factors, including the size and shape of the object exposed, its electric conductivity, and proximity to other conducting objects. Man's size and posture make it difficult to simulate in laboratory animals upon a number of factors, including grounding conditions, the magnitude of contact current, the duration of current flow, and body mass. Currents above the 10-mA level represent a serious risk because the "let-go" threshold[†] may be exceeded, and the individual might not be able to release a charged object due to involuntary muscle contractions (IEEE 1978, 1984). The estimated level of let-go current in small children is approximately one-half of that for an adult man. If the current is increased beyond the let-go value, there is a possibility that ventricular fibrillation can occur. Short-circuit currents resulting from touching charged objects can be related to unperturbed field strengths (Guy 1985).

Typical threshold values resulting from steady-state contact currents of 50/60 Hz from vehicles (IEEE 1978; Zaffanella and Deno 1978; UNEP/WHO/IRPA 1984) include:

- 10–12 kV m^{-1}: Median pain perception for children, finger contact, car;
- 8–10 kV m^{-1}: Painful shock for children, finger contact, truck;
- 4–5 kV m^{-1}: Median touch perception for men, finger contact, car;
- 2–2.5 kV m^{-1}: Median touch perception for children, finger contact, car.

Transient capacitative discharges can occur between a person and a charged object via a spark through an air gap. The human reaction to transient electric shocks from spark discharges has been shown to depend in a complex manner on the discharge voltage and the capacitance of the discharging object (IEEE 1978). The sensitivity of individuals to transient discharges has a linear dependence on body mass (Larkin et al. 1986). Other factors such as sex, age, or skin hardness have no correlation with the threshold sensitivity of an individual to transient electric discharges. Data obtained on adults exposed to spark discharges of various intensities showed that 50% of the subjects perceived spark discharges in a field of 2.7 kV m^{-1}, and 50% found the spark discharges annoying at 7 kV m^{-1} (Zaffanella and Deno 1978). To obtain these data, persons standing in an electric field touched a metallic post with a finger; it is assumed that their capacitance was of the order of 170 pF.

Derivation of exposure limits. The proposed criterion of induced current density of 10 mA m^{-2} in the body is within the range of magnitude of spontaneous endogenous current densities. Our knowledge about the possible effects of long-term exposures to fields inducing currents near the criterion value is still limited, and most evidence is based on short-term observations.

In view of these reservations, the continuous occupational exposure should be limited to 10 kV m^{-1}, inducing a current density of 4 mA m^{-2} on average. There is substantial workplace experience, in addition to controlled laboratory studies on volunteers, which indicate that short-term exposures to fields up to 30 kV m^{-1} have no significant adverse health consequences. Exposures to electric fields between 10 and 30 kV m^{-1} produce proportionally increasing discomfort and stress and should be limited in duration accordingly. A practical approach to limiting the duration of exposure to fields between 10 and 30 kV m^{-1} is to use the formula $t \leq 80/E$ over the whole working day, where t is the duration of exposure in hours to a field strength of E kV m^{-1}.

For the reasons given in the Population sub-section, a further safety factor was incorporated for exposure of the general public. A safety factor of five with respect to the criterion of 10 mA m^{-2} was introduced, leading to a limit of 2 mA m^{-2} which corresponds to an electric field strength of 5 kV m^{-1}.

The limit of 5 kV m^{-1} for continuous exposure of the general public also provides substantial protection from annoyance caused by steady-state contact currents or transient discharges. This limit, however, cannot completely eliminate perception of the electric field effects, since the perception threshold for some people is below 5 kV m^{-1}. In such cases, additional technical measures (e.g., grounding) may be instituted to avoid indirect coupling effects arising from touching charged, ungrounded objects. It should be noted that continuous exposures of the general public outdoors rarely exceed 1–2 kV m^{-1} (Tenforde and Kaune 1987).

Rationale for limits on magnetic field exposures

In terms of a health risk assessment, it is difficult to correlate precisely the internal tissue current densities with the external magnetic flux density. Assuming a 10-cm radius loop in tissue of conductivity 0.2 S m^{-1}, it is possible to calculate the magnetic flux density that would produce potentially hazardous current densities in tissues. The following statements can be made for induced current density ranges and magnetic flux densities of sinusoidal homogeneous fields that produce biological effects from whole-body exposure (UNEP/WHO/IRPA 1987):

a) Between 1 and 10 mA m^{-2} (induced by magnetic flux densities above 0.5 and up to 5 mT at 50/60 Hz)—minor biological effects have been reported.

b) Between 10 and 100 mA m^{-2} (above 5 and up to 50 mT at 50/60 Hz)—there are well-established effects, including visual and nervous system effects.

c) Between 100 and 1000 mA m^{-2} (above 50 and up to 500 mT at 50/60 Hz)—stimulation of excitable tissue is observed and there are possible health hazards.

d) Above 1000 mA m^{-2} (greater than 500 mT at 50/60 Hz)—extra systoles and ventricular fibrillation can occur (acute health hazards).

Several laboratory studies have been conducted on human subjects exposed to sinusoidally time-varying magnetic fields with frequencies of 50/60 Hz. None of

[†] The let-go threshold is the current intensity above which a person cannot let go of a gripped conductor as long as the stimulus persists due to uncontrollable muscle contraction.

the current densities that occur when man is exposed to strong electric fields. The species differences between man and laboratory animals may result in differences in the threshold for biological responses, the magnitude of physiological responses, and the degree of adaptation.

A physical basis for extrapolations, or what is called "scaling" from animal to human subjects, was provided by recent dosimetric studies. Comparing enhancement of fields at body surfaces and internal current densities, comparisons of exposure can be made. According to a study by Kaune et al. (1985), exposure of pigs to an effective electric field strength of 25 kV m^{-1} is equivalent to human exposure at 9.3 kV m^{-1} if peak electric field strengths at the surface of the body are taken into account, and 13 kV m^{-1} if the average electric field strength at the surface is considered. Using average total current densities in the torso as a scaling factor, Kaune and Forsythe (1988) derived approximate values for comparisons of exposure of humans, swine, and rats. Electric fields at 60 Hz result in current densities 7.3 times larger in humans than in swine, and 12.5 times larger in humans than in rats at the same unperturbed field strength. Exposure of rats at 100 kV m^{-1} is roughly equivalent to human exposure at 8 kV m^{-1}, and exposure of swine at 100 kV m^{-1} to human exposure at 13.7 kV m^{-1}. Thus animal experiments suggest that prolonged exposure to fields in the range of 8 to 15 kV m^{-1} does not lead to evident adverse effects in humans (Czerski 1988).

Experimental studies. A large body of data has been collected on blood chemistry changes in animals exposed under different conditions; no consistent picture of physiological changes is evident.

Results of behavioral experiments on animals, which suggested an effect of exposure, were at levels at or above those needed for sensory perception of the field. Most behavioral tests showed no effects with exposure to electric field strengths up to 10 kV m^{-1} (UNEP/WHO/IRPA 1984; Ahlbom et al. 1987). Effects on behavior have been reported in isolated instances from electric field exposure inducing current densities as low as 3 mA m^{-2}. Health consequences, if any, of these observations require further studies.

Many studies on laboratory animals (rodents) have indicated that there are no significant adverse effects on growth and development. Multi-generation studies in swine and rats exposed to electric fields (30 kV m^{-1} and 65 kV m^{-1}, respectively) revealed developmental defects (Phillips 1981; Phillips 1985). These results were not confirmed in recent, well-controlled studies on rats (Rommereim et al. 1988; Sikov et al. 1987).

Evaluation of the evidence from many studies indicates that animal morbidity and mortality are unaffected by long-term exposure. Such studies were carried out on small laboratory animals (rats and mice) at unperturbed 50/60 Hz electric field strengths up to 100 kV m^{-1} (Bonnell et al. 1986) and on larger animals, including miniature pigs, at levels near 30 kV m^{-1} (Phillips 1981, 1985).

Human studies. At 50/60 Hz, a field strength of 20 kV m^{-1} is the perception threshold of 50% of people for sensation from their head hair or tingling between body and clothes. As shown under laboratory conditions, a small percentage of people can perceive a field strength of 2 or 3 kV m^{-1} (Cabanes and Gary 1981; IEEE 1978).

Controlled laboratory studies on volunteers exposed for short periods to electric field strengths of up to 20 kV m^{-1} have, in general, shown no significant effects (Hauf and Wiesinger 1973; Hauf 1974; Rupilius 1976; Sander et al. 1982). These data do not establish that health effects could not occur from long-term exposure (months or years).

Well-controlled studies on the health status of linemen and switchyard workers have not revealed any statistically significant differences between exposed and control groups (Knave et al. 1979; Stopps and Janischewsky 1979; Baroncelli et al. 1986). These studies are among the more complete and are representative of high levels of occupational exposure. Because of the small populations studied and the resulting low statistical power, these studies cannot exclude the existence of small effects in these highly exposed populations.

Several studies of the incidence of cancer or mortality from cancer among arbitrarily defined occupational groups considered to be exposed to electromagnetic fields (among other factors) suggested an association between "electrical occupations" and cancer. Because of the inherent uncertainty associated with this type of epidemiological study and the lack of measurement of exposure, no definitive conclusion can be drawn. However, the questions raised by these reports necessitate further investigation (UNEP/WHO/IRPA 1984, 1987; Repacholi 1988).

Recent epidemiological studies (Savitz et al. 1988) provided some support for the findings of a previous study on childhood cancer and exposure to weak electric fields (Wertheimer and Leeper 1979). Both studies were carried out in the same geographical area and on a similar population; thus, the conclusions drawn from both reports cannot be generalized. A scientific panel (Ahlbom et al. 1987) which evaluated the implications of these epidemiological studies concluded that the association between cancer incidence and 60 Hz field exposure is still not established and remains a hypothesis. The Committee concurs with this conclusion. To date, chronic low-level exposure to 50/60 Hz fields has not been established to increase the risk of cancer.

From the experimental data and human studies, it was concluded (UNEP/WHO/IRPA 1984) that no adverse health effects resulted from short-term exposures at strengths up to 20 kV m^{-1} at frequencies of 50 and 60 Hz.

Steady-state 50/60 Hz current from contact with charged objects can produce biological effects that range from just noticeable perception to ventricular fibrillation and death (UNEP/WHO/IRPA 1984). The severity of an electric shock from touching a charged object depends these investigations has revealed adverse clinical or physiological changes. The strongest magnetic flux density used in these studies with human volunteers was a 5-mT, 50-Hz field to which subjects were exposed for 4 h.

Some epidemiological reports present data indicative of an increase in the incidence of cancer among children, adults, and occupational groups. The studies suggest an association with exposure to weak 50- or 60-Hz magnetic fields. These associations cannot be satisfactorily explained by the available theoretical basis for the interaction of 50/60 Hz electromagnetic fields with living systems. The magnetic flux densities in some epidemiological studies suggesting an increased cancer incidence are at values near 0.25 μT. This magnetic flux density would induce a current density that is well below those levels normally occurring in the body. The epidemiological studies are not conclusive. Although these epidemiological data cannot lismissed, there must be additional studies before they serve as a basis for health hazard assessment. Furthermore, scant laboratory evidence is available to support the hypothesis that there is an association between 50/60 Hz fields and increased cancer risk.

The total number of direct observations of the effect of magnetic flux densities in humans is limited. Controlled laboratory studies on human volunteers exposed for 4 to 6 h d^{-1} for several days to magnetic flux densities up to 5 mT (together with electric fields up to 20 kV m^{-1}) did not demonstrate significant effects (UNEP/WHO/IRPA 1987; Sander et al. 1982). Therefore the short-term occupational exposure should not exceed 5 mT (inducing current densities of 10 mA m^{-2}, the criterion value) and 25 mT for the extremities. The latter value takes into account the loop diameters in the limbs which are about one-fifth of those in the trunk. Because of the sparseness of data on long-term exposures to magnetic fields, the magnetic flux density for continuous exposure in the occupational environment is limited to 0.5 mT, a limitation hich can be accepted without great difficulty in most upational environments.

For reasons developed earlier, the limit for continuous exposure of the general public was set at 0.1 mT, a factor of five below the limit for continuous occupational exposure; the short-term exposure limit was set at 1 mT.

Typical office and household average levels are 0.01–1 μT (Gauger 1984). Values of up to 12 μT may occur intermittently in rooms heated using electric/oil heaters (Krause 1986) as well as peak levels of 1–30 μT at a 30-cm distance from various appliances; magnetic flux densities from power transmission systems are somewhat higher and can typically approach levels of about 10–30 μT (Bernhardt 1988; Tenforde and Kaune 1987; UNEP/WHO/IRPA 1987). However, near (3.0 cm) some appliances like electric blankets, hair dryers, shavers, and magnetic mains voltage stabilizers, the magnetic flux density can approach levels of 0.1–1 mT. Because of the strong inhomogeneity of magnetic fields near most appliances, the magnetic flux density should be averaged on a loop surface of 100 cm^2 to simulate a realistic current loop in the human body.

Cardiac pacemakers

Interference of electric fields with implanted cardiac pacemakers can lead to reversion to a fixed rate; cessation of stimulation is possible. Such direct interference has not been reported in fields below 2.5 kVm^{-1} (UNEP/WHO/IRPA 1984; Moss and Carstensen 1985). Although body currents produced by contact with a vehicle in a weaker field may cause interference, the risk of pacemaker reversion is believed to be slight (UNEP/WHO/IRPA 1984).

The probability that a malfunction will occur in the presence of an external magnetic field is strongly dependent on the pacemaker model, the value of the programmed sensing voltage, and the area of the pacemaker loop which is determined during implantation. Assuming sensitivities of 0.5 to 2 mV for 50/60 Hz and worst-case conditions (600 cm^2 for the area of the pacemaker electrode, homogeneous field perpendicular to this area), interference magnetic flux densities of 15 to 60 μT may be calculated. Similar results were obtained by other authors (Bridges and Frazier 1979). For more realistic conditions, due to the inhomogeneity of magnetic fields, smaller effective loop areas, and smaller sensitivities of the signal-sensing circuit, there is only a small probability of the occurrence of a pacemaker malfunction at magnetic flux densities below about 100–200 μT (UNEP/WHO/IRPA 1987).

Increased sophistication of pacemakers has made the question of possible electromagnetic interference more difficult. Physicians implanting (and/or programming) very sensitive unipolar-demand pacemakers should be informed by the manufacturer that malfunction of the pacemaker can occur in a strong electric field so the patient can receive a detailed warning, e.g., avoiding areas with strong electric fields. A reduction of the susceptibility of pacemakers to electromagnetic interference is recommended.

Acknowledgment—The International Non-Ionizing Radiation Committee is funded by the International Radiation Protection Association. The support of the World Health Organization, the United Nations Environment Programme, the International Labour Office, and the Commission of the European Communities is gratefully acknowledged.

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APPENDIX 6

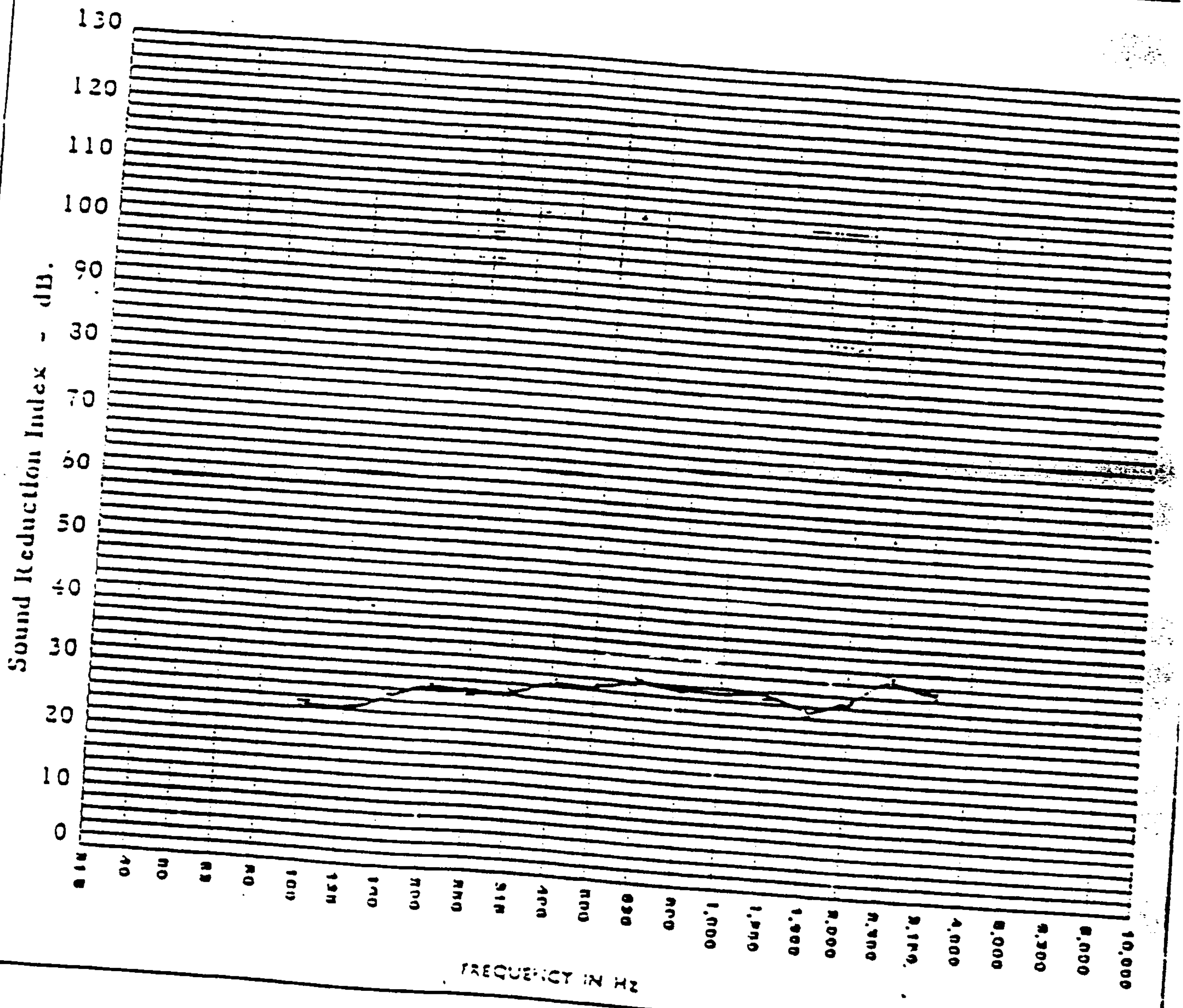
APPENDIX C

AIRO
ACOUSTICAL INVESTIGATION & RESEARCH ORGANISATION LIMITED

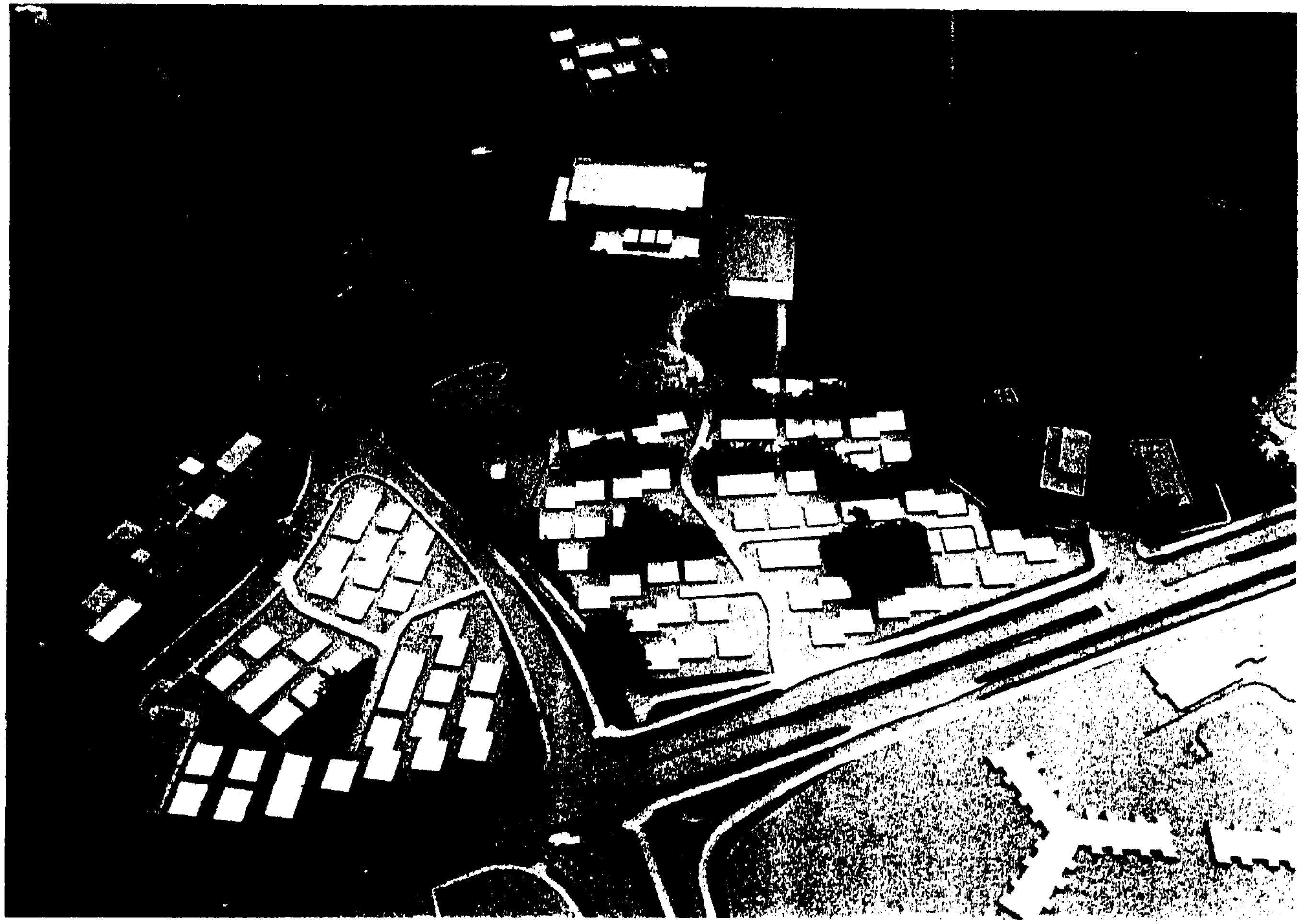
DATA SHEET

DATE	January, 1977.	No. L. 1427.
CLIENT	DURASTEEL LTD..	

Measurements of the Sound Reduction Index of a 3000 x 3000 x 9.5 mm thick 3 DF2 partition.



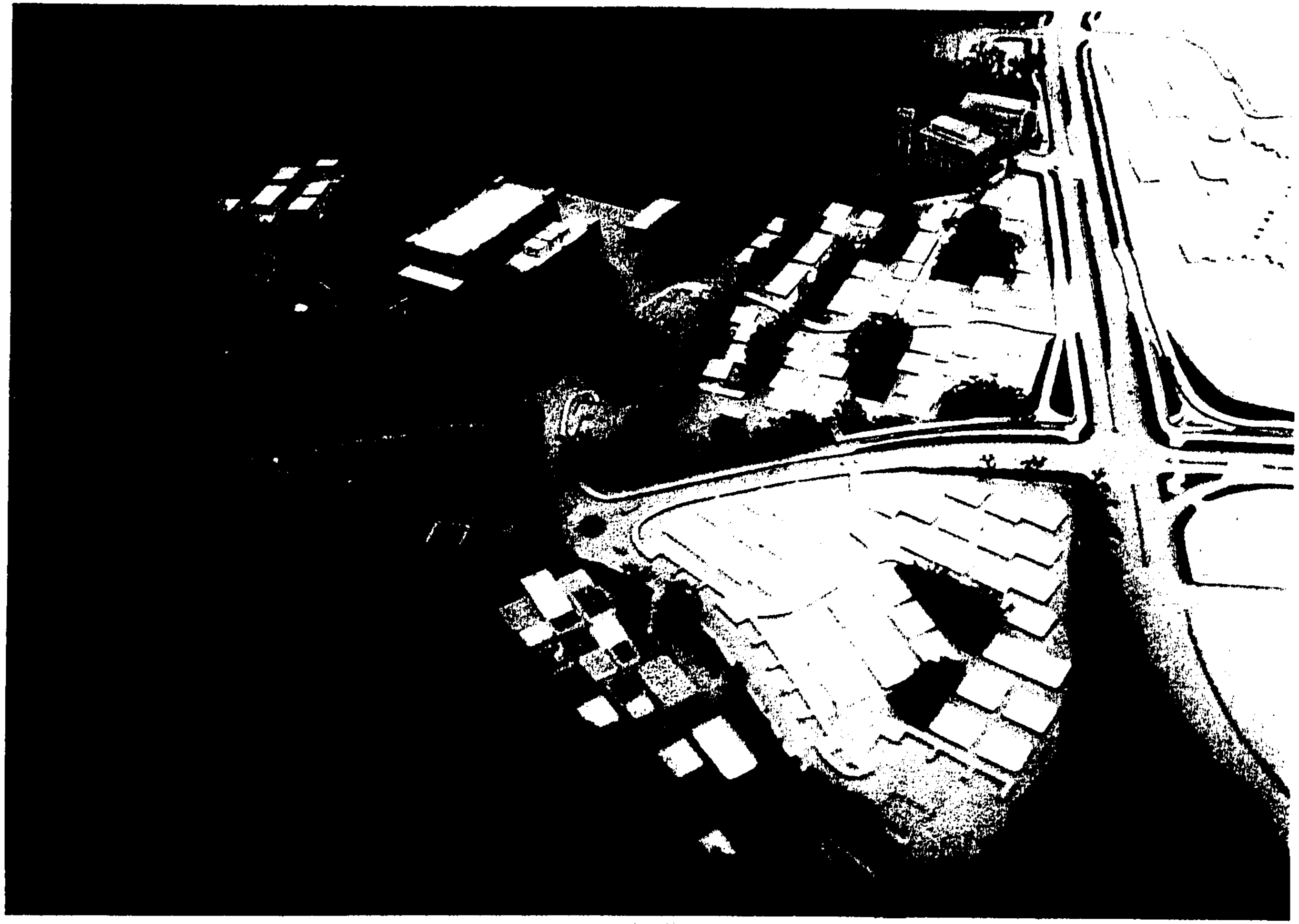
APPENDIX 7



VIEW OF THE SUBSTATION FROM THE SOUTH

APPENDIX 8

VIEW OF THE SUBSTATION FROM THE SOUTH

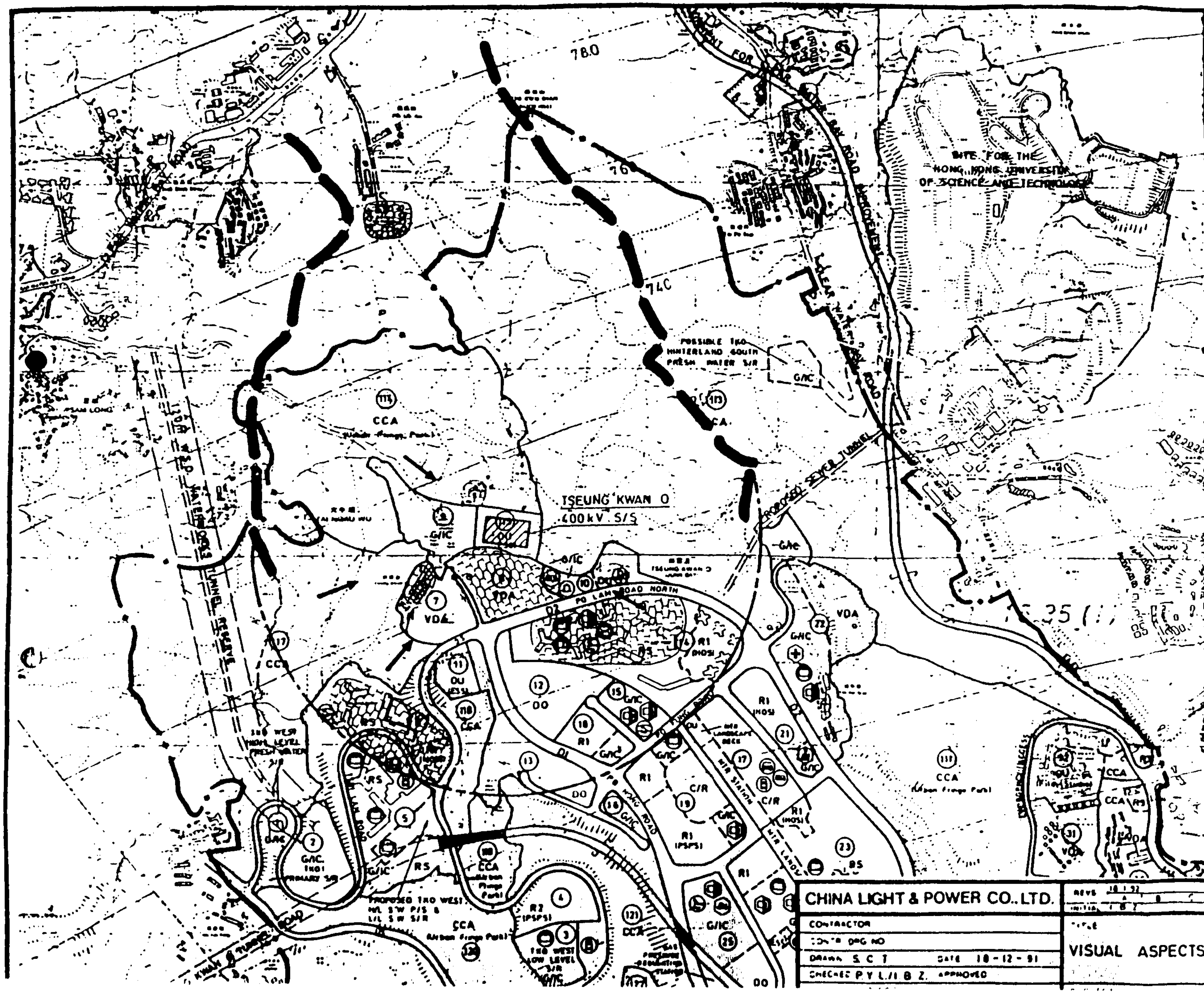


VIEW OF THE SUBSTATION FROM THE SOUTH-WEST

VIEW OF THE SUBSTATION FROM THE EAST

APPENDIX 9

APPENDIX 9
(REVISED)



LEGEND:

TERRAIN OBSTRUCTING VIEWS

SENSITIVE RECEPTORS

DIRECTION OF VIEW FOR PHOTOMONTAGES

LIMIT OF VISUAL ENVELOPE

CHINA LIGHT & POWER CO. LTD.

CONTRACTOR

CONTR DRG NO

DRAWN S C T DATE 18-12-91

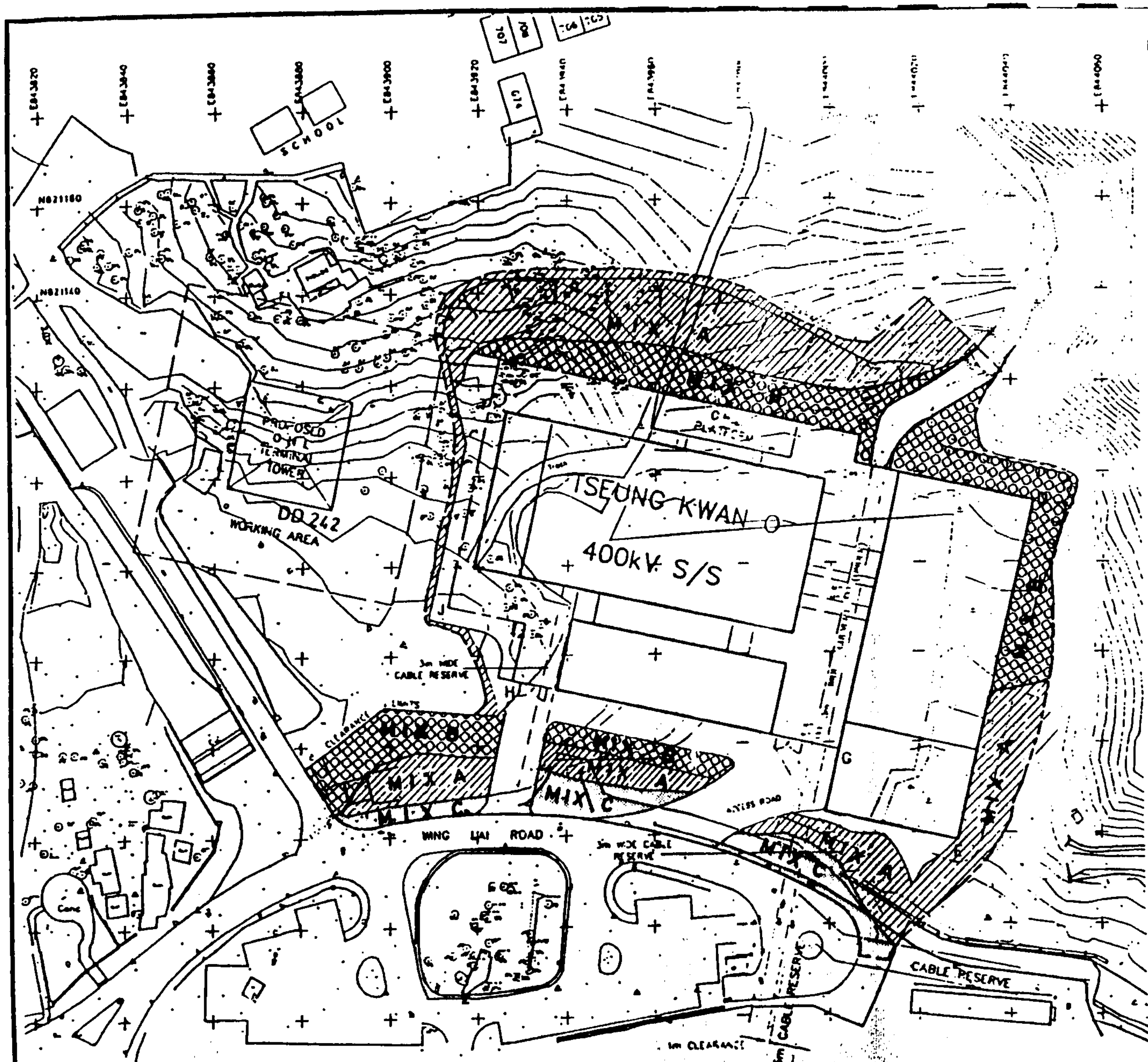
CHECKED P Y L / I B Z. APPROVED

REVS 18.1.92

TITLE

VISUAL ASPECTS — TSEUNG KWAN O 400 kV S/S

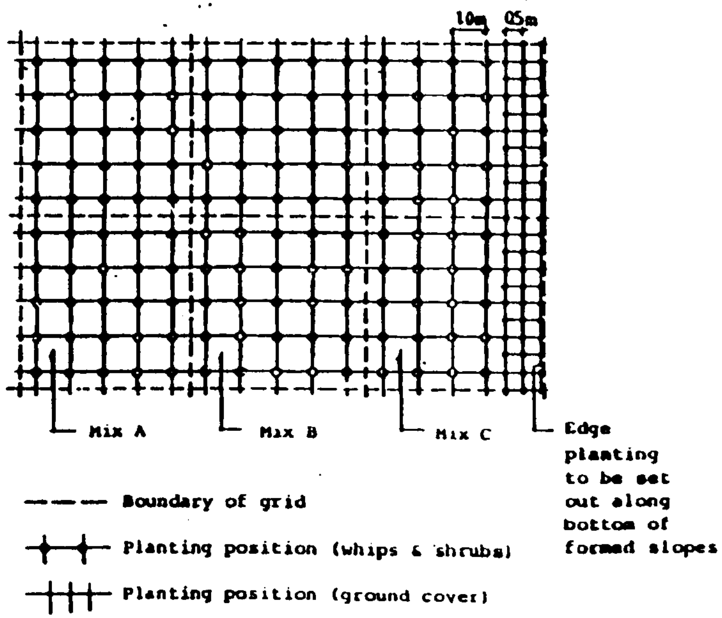
APPENDIX 10



NOTES

1. All planting to be at 1.0m centres unless otherwise noted.
2. Specific boundaries of planting areas shall be delineated on site by the Landscape Contractor for approval by the Landscape Architect.
3. Planting should take place over the areas marked on plan to the edge of existing woodland at the top of the slopes or site boundary, whichever shall apply.
4. All modifications to the planting grid resulting from landform or curves etc. to be approved by the Landscape Architect on site.
5. Orientation of grid to be determined on site to the approval of the Landscape Architect.
6. No tree species shall be planted within 1.5m of any concrete surface like drainage channel or cable reserve/tunnels.

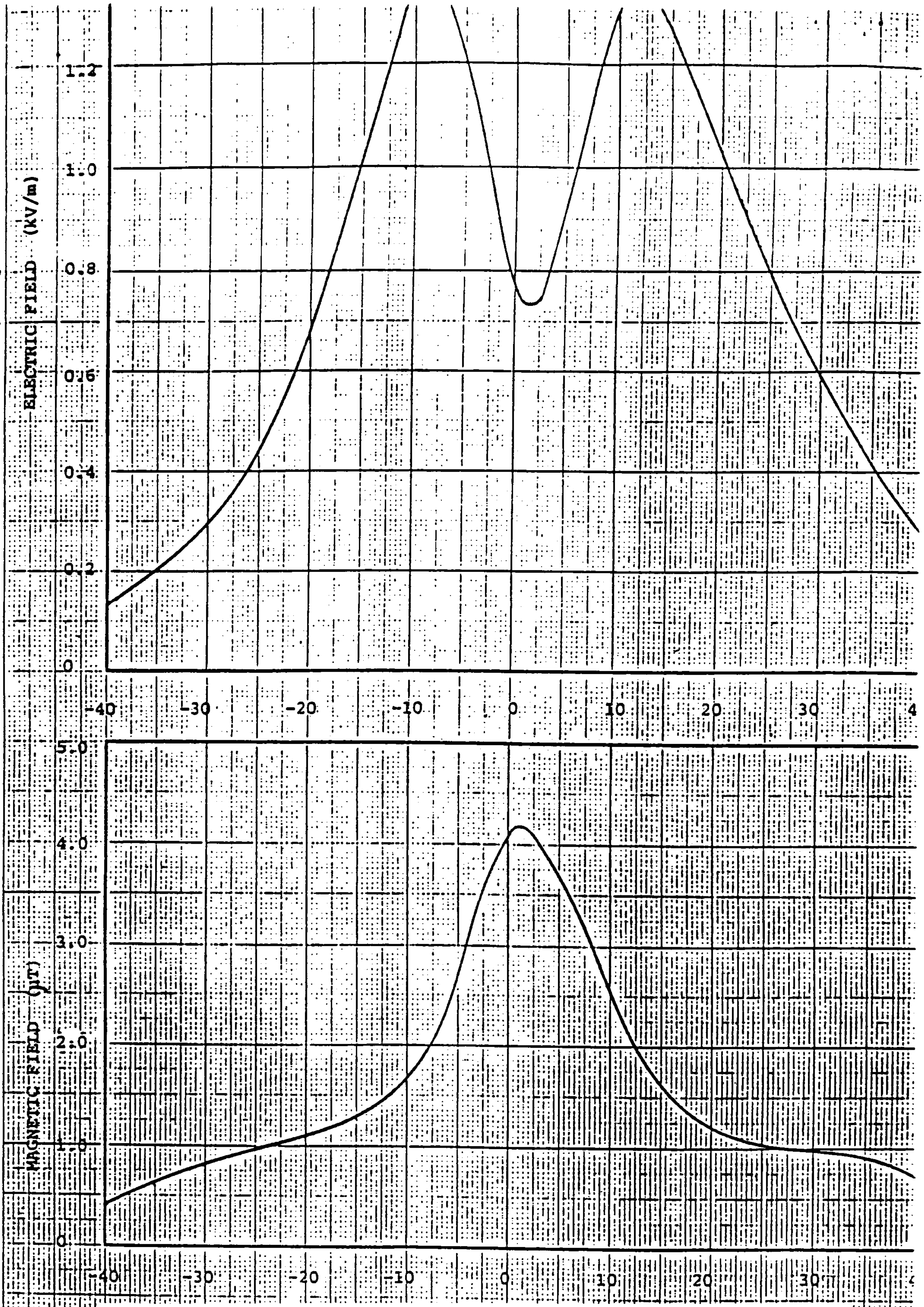
WHIP PLANTING GRID



APPENDIX 10

CHINA LIGHT & POWER CO., LTD.	REVS: A B C D E F G H
CONTRACTOR	TITLE: TSEUNG KWAN O 400kV SUBSTATION PROPOSED LANDSCAPING LAYOUT
CONTR DRG NO.	
DRAWN C.M.C. / DATE 23-12-91	
CHECKED P.Y.L. / I B Z / APPROVED	

APPENDIX 11



HORIZONTAL DISTANCE (m) from Centre of Powerline Reserve

<u>CASTLE PEAK - YUEN LONG 400kV OVERHEAD LINES</u>

Magnetic and Electric Field Strengths at Ground Level

APPENDIX 12

CHINA LIGHT AND POWER COMPANY LIMITED

Scientific and Technical Services Department

Scientific Services Branch

NOISE IMPACT ASSESSMENT OF THE JUNK BAY EHV SUBSTATION : PRE-COMMISSIONING ASSESSMENT

Report No. : SSB/ES/R119-90

Date of issue : March 1990

Work done by : F.N. Wong, W.S. Kwok, H.W. Cheng (Environmental Section)

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Circulation at date of issue : Mr. J. Woods - Divisional Manager - Engineering
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Mr. H. Kay - Snr. Trans. Proj. Engr. - S/S
Mr. A.N. Clark - Snr. Trans. Proj. Engr. - Systems

Mr. D. Leung - STS Engineer
Dr. A. Ashton - Actg. Scientific Services Officer
Mr. B. Manifold - Snr. Environmental Officer

CLASSIFICATION : UNRESTRICTED

Noise Impact Assessment of the Proposed Junk Bay EHV Substation : Pre-commissioning Assessment

SUMMARY

Noise surveys and measurements have been conducted in the vicinity of the proposed Junk Bay EHV substation in the hope of establishing baseline data on existing background noise levels.

Measured noise levels ranged from an average of 50-62 dB(A) during the day and 38-52 dB(A) at night. Day to day noise climate variation was found to be very little.

Calculations have indicated that noise nuisance is very likely to occur at future noise sensitive developments lying to the south-east, south and north of the proposed substation. Noise abatement measures are therefore necessary and a number of options have been recommended which include erection of acoustic barriers in various locations and relocation of either the shunt reactors or the noise sensitive uses.

Approved for issue

A. Ashton

Dr. A. Ashton
Acting Scientific Services Officer

INTRODUCTION

To facilitate future development in the region, CLP have requested the reservation of a site from the Government at Junk Bay for the erection of an EHV substation (Figure 1). The proposed substation will be designed to house six 240MVA 400/132kV transformers, some reactive compensation equipment and some switching and protection devices. Furthermore, additional equipment is tentatively planned to facilitate connections to the Hong Kong Electric grid system; however no definite decision has yet been made at this stage.

At the request of the Transmission Projects Department and as an aid to decision making to assess the suitability of the site for an electrical substation, a noise impact assessment has been prepared with the following objectives :-

1. To establish baseline noise data prior to commissioning of the substation so that comparisons can be made later with post-commissioning data.

2. To predict the extent of impact on areas likely to experience noise levels in excess of the "pre-existing" baseline noise levels.

3. To provide guidance on the noise control measures which could be incorporated into the design of the substation if the Noise Control Ordinance is likely to be breached.

This report addresses the above objectives and evaluates the potential for noise nuisance to arise from the predicted results. The main plant that need special attention are the six 240MVA transformers which will be housed in 'Building A' and the two shunt reactors which will be installed in the adjoining 'Building C'.

METHOD

Standard acoustical principles and practices were employed in the measurements of the noise under investigation, following guidelines laid down in the Technical Memorandum (Ref. 6) to the Noise Control Ordinance. Sound instruments (Bruel & Kjaer sound level meter type 2230 and noise analyzer type 4426) complying with IEC publications 651:1979 (Type 1) and 804:1985 (Type I) were used throughout the investigation. They were calibrated, i.e. with a known signal and sound pressure level immediately prior to and following each measurement in order to ensure validity. Measurement data were recorded only when meteorological conditions were judged to be suitable.

Background Noise Survey

From land use and substation layout considerations, four sampling points, namely A, B, C & D, were selected for the determination of background noise levels (See Figure 2). For each survey site, ten minutes statistical noise descriptor L_{90}, i.e. the percentile noise level exceeded for 90% of the measurement time, was used to estimate the pre-existing "natural" background noise level in tl neighbourhood. All sites were visited on a rotational bas: during each measurement period and noise surveys and measurement were carried out on :

1. Friday, 24th December 1989 (2200-0200 hrs) - Late Evening & Night-time

2. Friday, 15th December 1989 (1400-1700 hrs) - Daytime

3. Wednesday, 20th December 1989 (2300-0400 hrs) - Night-time & Early Morning

4. Thursday, 8th March 1990 (1400-1700 hrs) - Daytime

Substation Noise Assessment

For the purpose of this assessment, five prediction points, marke P_1, P_2, P_3, B & C in Figure 2, have been used to assess the impac of the substation. The procedures detailed in the CEGB Desig Memorandum - "Suppression of Transformer Noise" have been used t predict the noise levels at these locations. For the sake o simplicity but without loss of accuracy, the following assumption have been made :-

1. that sound propagates hemispherically in free fiel conditions with a directivity factor of two.

2. that after being energised the noise level of th transformer is independent of loading.

3. that the ONAN and ONAF mode of operation of the transformer would be employed for night-time and daytime respectively. (ONAF refers to operation with forced air cooling while ONA refers to operation with natural air cooling)

On the basis of the IEC 551 type test and measurement method (Ref 4), the reference distance and noise level for the relevant mod of operations of the plant were obtained and listed as below :-

Table 1

Plant	Mode of Operation	Ref. Distance (m)	Ref. Level dB(A)
Transformer	ONAN ONAF	5.2 9.9	67.5 64.1
Shunt Reactor	Continuous	6.3	72.0

Slant Distances from Substation to Prediction Points

Prediction Point	From Centre of Building 'A' (m)	From Centre of Shunt Reactors (m)
P_1	91	-
P_2	210	235
P_3	120	105
B	110	70
C	130	65

Correction Factors

In order to account for factors other than distance attenuation, the predicted noise levels will be adjusted accordingly :-

1. Facade Reflection Correction

   A factor of +3 dB(A) will be added to the predicted levels in order to account for the increase in noise level due to reflection at the facade of the Noisė Sensitive Receiver under consideration.

2. Barrier Effect Correction

   A calculated factor will be substracted from the predicted levels wherever the line of sight is obstructed by the presence of a barrier structure. An example of derivation is given in Appendix A.

3. Tonality Correction

   The worst situation will be considered in all cases so that all the predicted levels will have a factor of 6 dB(A) added.

RESULTS

Area Sensitivity Rating (ASR)

At present, there are a large number of temporary structures, which are potentially noise sensitive in nature, located in the southern region of the proposed substation. Under the current Government's development scheme, these structures will be demolished and replaced by a number of village type developments in future. Thus in accordance with the Noise Control Ordinance guidelines, the neighbouring area would be classified as residential and rated as follows :-

Rating	Time Period	Acceptable Noise Level (ANL) dB(A)
A	2300 - 0700	50
	0700 - 2300	60

In fact, the present defined rating would be progressively les applicable and an urban rating of "B" would be more appropriate : the region is to be developed to its fullest extent in a few yeai time.

Average Background Noise Levels

Night-time & Early Morning Period

Sampling Site	Noise Level L_{90} dB(A)			
	Time Period			
	2300-2400	2400-0100	0100-0200	0200-0300
A	44.8	41.8	40.0	39.0
B	44.0	38.3	38.2	38.0
C	42.8	38.3	38.5	39.3
D	52 (118)*	46.3 (29)*	44.0 (22)*	42.0 (19)*

Lowest level = 38.0 dB(A)

Daytime Period

Sampling Site	Noise Level L_{90} dB(A)		
	Time Period		
	1400 - 1500	1500 - 1600	1600 - 1700
A	50.1	52.3	51.6
B	52.0	51.5	53.5
C	50.3	53.0	52.5
D	61.5 (112)*	59.5 (107)*	62.3 (128)*

Lowest level = 50.1 dB(A)

* - No. of vehicles passing the sampling point during the ten minutes measurement time period.

Predicted Noise Levels at Selected Points

Table 3

Location	Predicted Level L_p dB(A) Transformer ONAN	ONAF	Shunt Reactor	Combined Noise Level dB(A) ONAN	ONAF
P_1	50.4	52.6	-	50.4	52.6
P_2	40.2	42.4	43.6	45.2	46.1
P_3+	33.0	35.2	50.6	50.6	50.7
B	45.8	47.9	54.1	54.7	55.0
C	47.3	49.5	54.1	55.5	55.9

As mentioned previously, ONAF refers to operation of transformers in daytime (i.e. 0700 - 2300 hours) when demand in electricity is high and ONAN refers to operation in night-time (i.e. 2300 - 0700 hours) when loading drops considerably. With the addition of the 'Tonality' and 'Facade' correction terms the predicted noise levels are increased by a factor of 9 dB(A). The final corrected noise level is then called the Corrected Noise Level (CNL). For the purpose of this assessment, the Noise Criteria (NC)* to be compared against the predicted noise levels for night-time and daytime are taken to be 45 dB(A) and 55 dB(A) respectively.

Table 4

Location	2300 - 0700 hours		0700 - 2300 hours	
	CNL dB(A)	NC dB(A)	CNL dB(A)	NC dB(A)
P_1	59.4	45.0	61.6	55.0
P_2	54.2	45.0	55.1	55.0
P_3	59.6	45.0	59.7	55.0
B	63.7	45.0	64.0	55.0
C	64.5	45.0	64.9	55.0

---

* - Full elucidation see Discussion Section

\+ - Full derivation see Appendix A

DISCUSSION

As shown in Figure 2, those areas lying to the south-east, south and north of the substation will be developed as noise sensitive properties. Thus these are the areas likely to be seriously affected by noise from the substation and there is, in fact, already an existing Tseung Kwan O village located in the south-west part of the substation. With a view to minimising the noise emission levels, the proposed substation layout has made use of the 132kV Switchgear building as an acoustic barrier so that the areas to the south of the substation would benefit from the screening effect.

Baseline Data Establishment

Background noise levels fluctuated from 38 to 52 dB(A) during the night-time and early morning periods and from 50 to 62 dB(A) during daytime. Indeed, the recorded noise levels were dependant upon the time of the day and the measurement locations. For locations close to the main roads, such as sampling point D, traffic noise was clearly the dominant source and this was reflected in the measurement results. For locations close to the proposed substation boundaries the results have reflected the lower background noise climate as a result of the reduced influence of the main road traffic noise. Nevertheless the major noise sources constituting the existing background were identified and categorised as follows :-

1. Traffic along Road D5 & D2

2. Insects from existing woodland

3. Human activities and occasional dogs barking

Evaluation of Potential For Noise Nuisance

In making an assessment against the Corrected Noise Levels predicted, the noise criteria have been adopted (i.e. ANL-5), which are 45 and 55 dB(A) for night-time and daytime respectively. The reasons for adopting such working criteria are twofold. Firstly, the likely affected areas around the substation, according to the Government's plan, will be developed into structures of a residential nature. This would imply a growth in population rendering an increase in traffic flow rate and community activities. Consequently, the background noise levels will be increased in future. Secondly, a 6 dB(A) tonality correction has been incorporated into all predicted noise levels which will provide an appropriate margin of safety from a planning point of view since past survey experiences suggest that the tonality effect is noticeable only within a short distance of the source. The noise characteristics/spectrum will tend to be modified by any masking effects along with an increase in distance. Hence it is considered to be appropriate and realistic to adopt the above Noise Criteria.

In the event of noise complaints being made by members of the public and the possibility of enforcement by the Environmental Protection Department, it is necessary to follow the procedures described in the Noise Control Ordinanace in order to determine whether a statutory noise nuisance exists. From past experiences however, the general public tend to raise complaints when the intrusive noise is 5 dB(A) or more above the background level. In accordance with the Hong Kong Planning Standards & Guidelines (HKPS & G), such intruding noise level should not exceed the existing background level (L_{90}) at the facade of the Noise Sensitive Receivers (NSRs) in question.

The different aforementioned Noise Criteria which have been referred to separately are listed below for comparison purposes:-

Noise Criteria	Noise Level 2300 - 0700 hrs dB(A)	Noise Level 0700 - 2300 hrs dB(A)
NCO ANL	50.0	60.0
ANL-5	45.0	55.0
HKPS & G	41.0	53.1

By comparing the Corrected Noise Levels previously obtained with the above criteria, a breach of these criteria is therefore demonstrated.

Mitigation Measures

As shown above, with full commissioning of all the major plant and with the current proposed substation layout, a nuisance to its present and future noise sensitive receivers is likely. Noise mitigation measures are therefore considered necessary for prevent noise distance in the neighbourhood of the proposed EHV Substation. The most practicable and economic means in this case is to restrict the noise propagation path at source in relation to those directions which lie within the line of sight if the sensitive receivers. By this principle, calculations using acoustic barriers illustrated in Figure 3, have demonstrated the following levels of improvement :-

Predicted Uncorrected Noise Levels at Selected Points Following Additional Noise Attenuation Measures at the Substation

Location	Predicted Level L_p dB(A) Transformer ONAN	Transformer ONAF	Shunt Reactor	Combined Noise Level dB(A) ONAN	ONAF
P_1	35.4	37.6	-	35.4	37.6
P_2	37.2	39.4	35.0	39.2	40.7
P_3	33.0	35.2	40.8	41.4	41.8
B	30.8	32.9	43.1	43.3	43.5
C	32.3	34.5	43.3	43.3	43.8

Further comparison of the new corrected noise levels (i.e. with the added Tonality & Facade Corrections) with the selected Noise Criterion (NC) considered appropriate in this case, is presented as below :-

Location	2300 - 0700 hours		0700 - 2300 hours	
	CNL dB(A)	NC dB(A)	CNL dB(A)	NC dB(A)
P_1	44.4	45.0	46.6	55.0
P_2	48.2	45.0	49.7	55.0
P_3	50.4	45.0	50.8	55.0
B	52.3	45.0	52.5	55.0
C	52.3	45.0	52.8	55.0

The above results indicate that, the night-time and early morning periods may still give rise to noise complaints despite the installation of the proposed acoustic barriers. The shunt reactors have been identified as the most troublesome noise sources and further measures would need to be considered to achieve compliance with the suggested Noise Criterion. Various options are possible in this case, such as full enclosure of the reactors, relocation of the reactors or increasing the noise buffer zone. However, other problems such as ventilation or maintenance requirements, or land use restrictions, may arise as a result. Whether or not any balanced solution can be reached is dependent upon a number of factors, such as safety and maintenance difficulties, the scale of civil engineering work, availability of usable land, the degree of support from the Government, etc.

CONCLUSION

The pre-existing background noise levels recorded were extremely low, particularly in the early morning period when traffic along the main road D5 and D2 was virtually non-existent. However the background noise level could be anticipated to rise if the Government's development plan in the region is fully implemented.

Calculations on the expected noise levels from the EHV substation, with all the major plant operational, indicate that noise annoyance is likely to arise at night if future residential areas are located at points B, C and P_3. Mitigation measures are therefore recommended to be incorporated into the substation design in order to achieve the required improvement. This could be achieved by the construction of the acoustic barriers suggested (i.e. in Building 'A', between Buildings A and B, and in Building C possibly), and either the full enclosure or relocation of the shunt reactor in order that full compliance with the Noise Criteria can be met.

RECOMMENDATIONS

The recommended options are in the order of preference as follows :-

1. Erect acoustic barriers 1, 2 and 3, as shown in Figure 3, with provision for enclosing the reactor should post-commissioning surveys or noise enforcement measures make it necessary but with recommendations to the Government that noise sensitive uses be constructed no closer than 120m from the centre of the current reactor location.

2. Erect acoustic barriers 1, 2 and 3 and allow provision to fully enclose the reactors if post-commissioning assessment proves to be necessary.

3. Erect acoustic barriers 1 and 2 and relocate the reactors as shown in Figure 3, together with the barrier structure 3.

REFERENCES

1. CLP Memorandum Ref. No. 214-187/1261/89/JFB/SWT dated 3rd November, 1989
"Environmental Impact Assessment for Proposed Site of Junk Bay 400kV Substation".

2. "Transformer Test Report" - Mitsubishi Electric Corp., Janpan.

3. "Shunt Reactor Test Report" - Fuji Electric Co. Ltd., Chiba Factory.

4. IEC Standard Publication 551 : "Suppression of Transformer Noise" - International Electrochemical Commission, Geneva (1976).

5. CEGB Design Memorandum 077/507 : "Suppression of Transformer Noise" - Central Electricity Generating Board, U.K. (1969).

6. "Technical Memorandum for the Assessment of Noise from Places Other than Domestic Premises, Public Places or Construction Sites" - Special Supplement No. 5 to the H.K. Government Gazette Extraordinary P.E 157-167 [7.11.1988].

7. "Environmental Guidelines for Planning in Hong Kong" - June 1986
- An extract from the Hong Kong Planning Standard & Guidelines : Hong Kong Government.

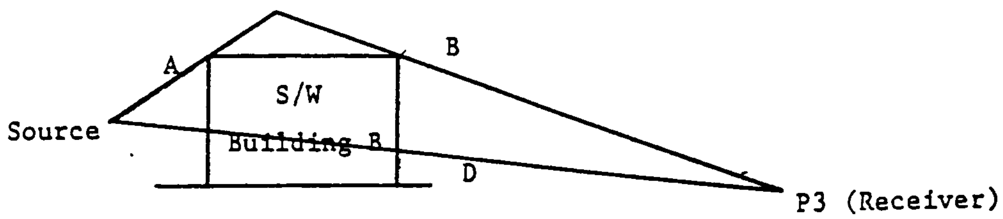
8. "Acoustic Noise Measurements" dated June 1988
- By Bruel & Kjaer.

APPENDIX A

Sample Calculation of the Barrier Effect

The screening effect due to the 132kV switchgear building is calculated by the Fresnel Equation with the following assumptions made :-

- point source
- no reflections
- barrier infinitely long
- barrier transmission loss (TL) much greater than diffracted components



$$\text{Attenuation} = 20 \log \left(\frac{\sqrt{2 \pi N}}{\tanh \sqrt{2 \pi N}} \right) + 5 \text{ dB}$$

where $N = \left[2 \cdot (A + B - D) \times f\right] / C$

f = hum frequency 100Hz

C = speed of sound in air (344 ms^{-1})

D = distance from source to receiver

A, B = slant distance over barrier

For A = 23.05m, B = 92.4m, D = 111.9m, the attenuation is worked out be **16.1 dB(A)** at 100Hz.

FIGURE 1

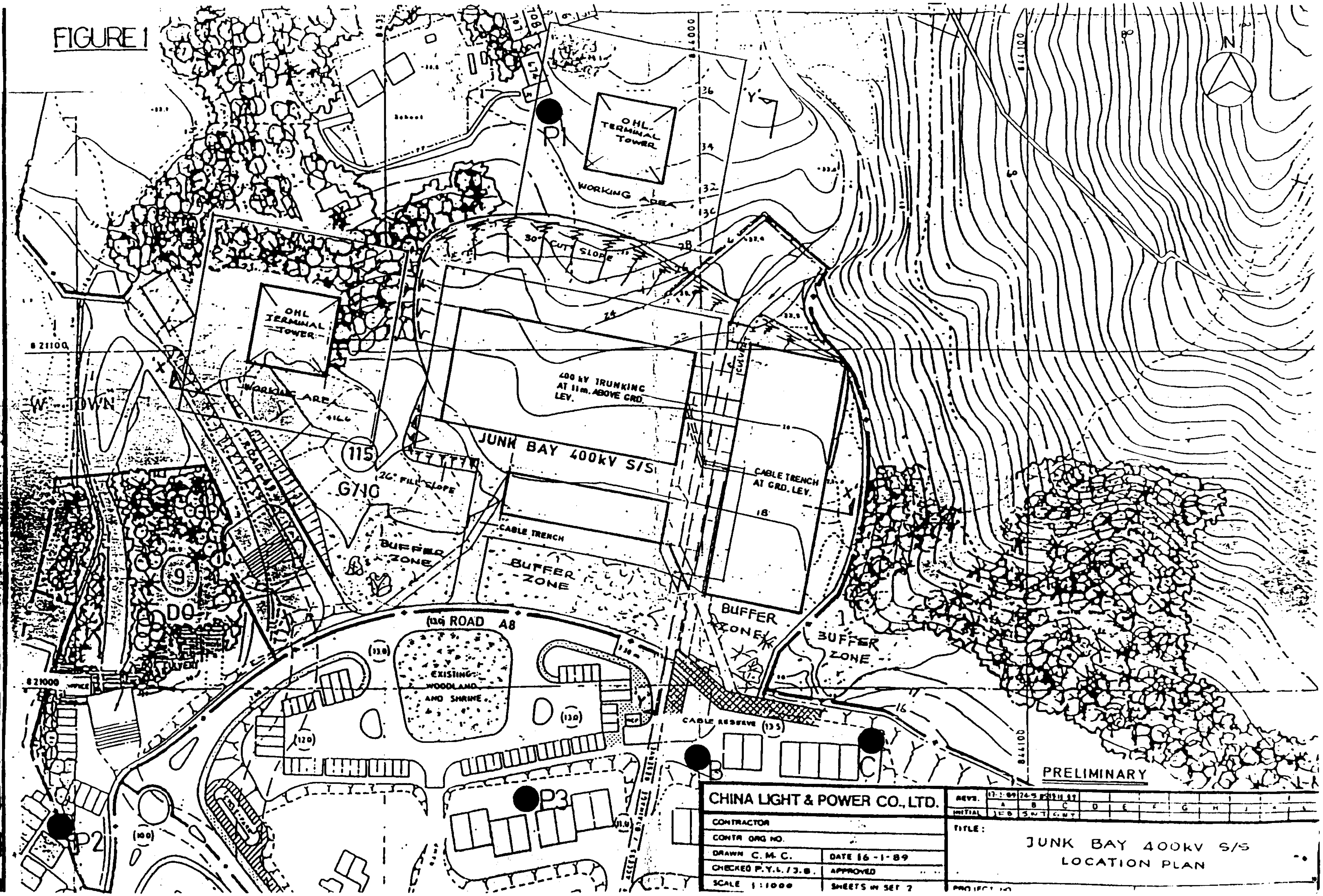
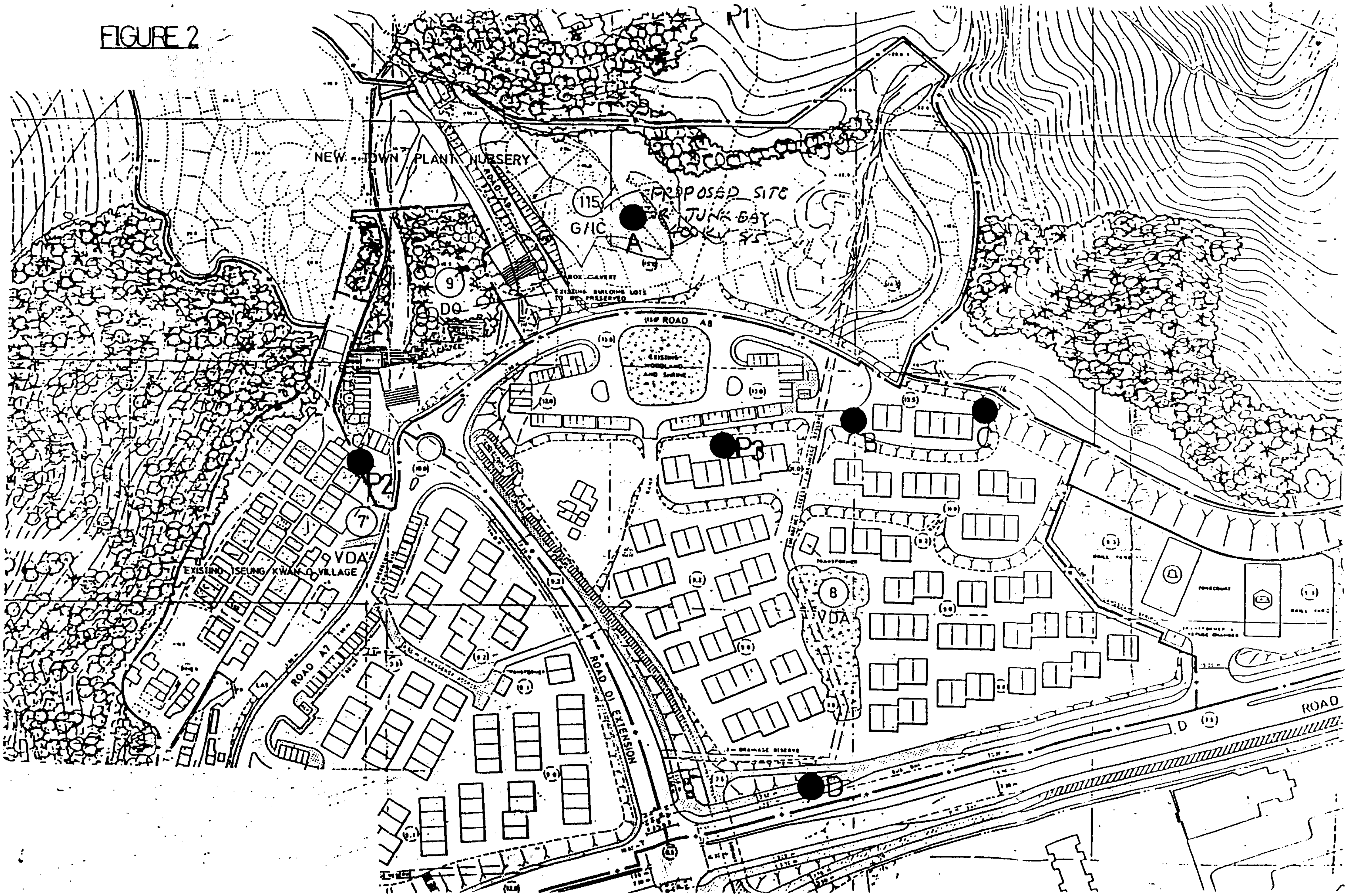
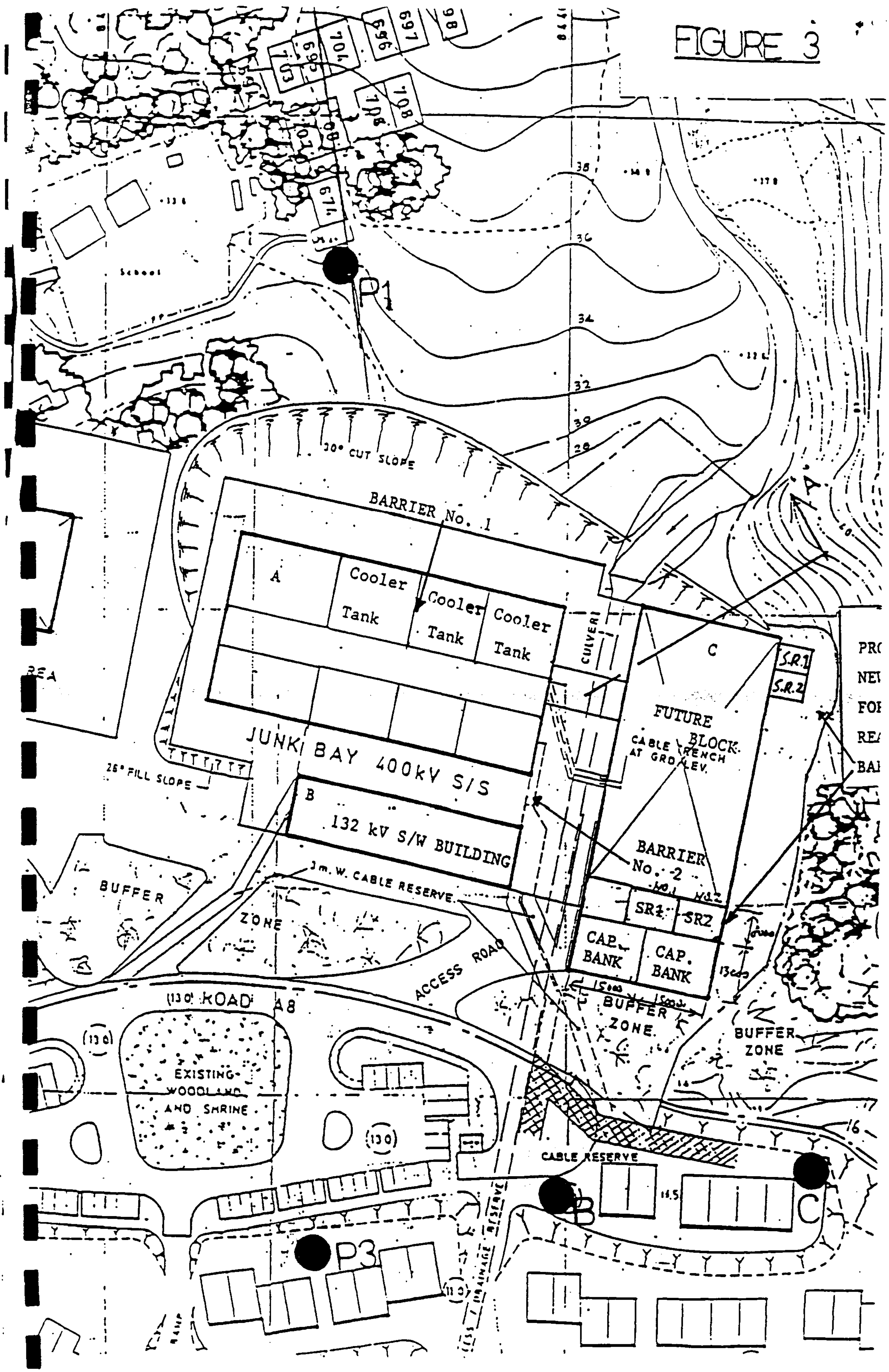

N
OHL TERMINAL TOWER
WORKING AREA
30° CUT SLOPE
OHL TERMINAL TOWER
WORKING AREA
400 kV TRUNKING AT 11m. ABOVE GRD. LEV.
JUNK BAY 400kV S/S
CABLE TRENCH AT GRD. LEV.
CABLE TRENCH
20° FILL SLOPE
115
G/IC
BUFFER ZONE
BUFFER ZONE
BUFFER ZONE
BUFFER ZONE
ROAD A8
EXISTING WOODLAND AND SHRINE
CABLE RESERVE
P1
P2
P3
B
C
9
DO
PRELIMINARY
CHINA LIGHT & POWER CO., LTD.
CONTRACTOR
CONTR. DRG NO.
DRAWN C. M. C.
DATE 16-1-89
CHECKED P. Y. L. / J. B.
APPROVED
SCALE 1:1000
SHEETS IN SET 2
TITLE:
JUNK BAY 400kV S/S
LOCATION PLAN

FIGURE 2



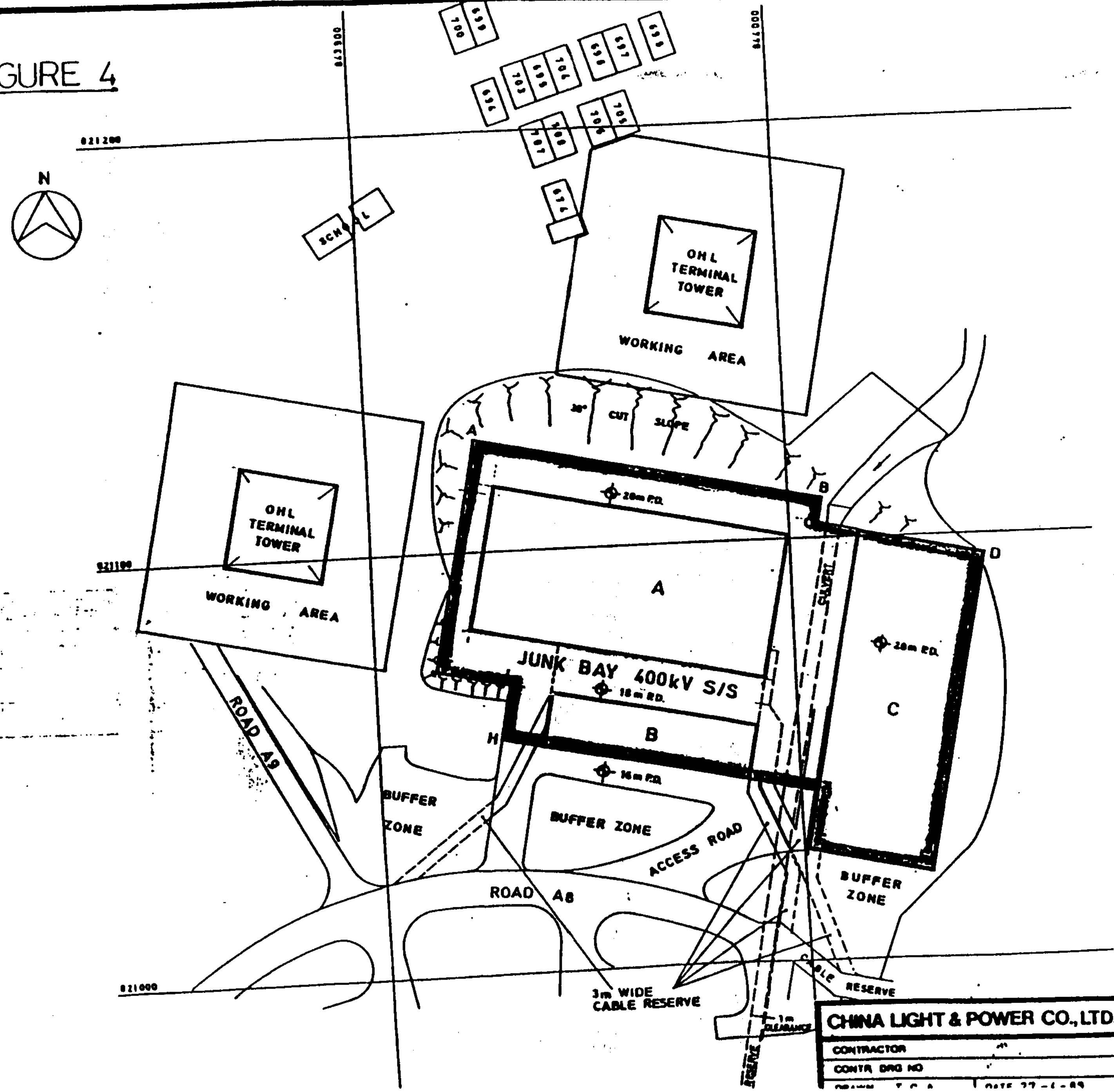
NEW TOWN PLANT NURSERY
PROPOSED SITE FOR JUNK BAY
115
G/IC
A
P1
9
DO
ROAD A8
EXISTING WOODLAND AND SHRINE
P2
'7'
VDA
EXISTING TSEUNG KWAN O VILLAGE
P3
B
C
8
VDA
ROAD A7
ROAD D1 EXTENSION
D
ROAD D

FIGURE 3



School
P1
30° CUT SLOPE
BARRIER No. 1
A
Cooler
Tank
Cooler
Tank
Cooler
Tank
CULVERT
C
S.R.1
S.R.2
FUTURE
BLOCK
CABLE TRENCH
AT GRD. LEV.
JUNK BAY 400kV S/S
25° FILL SLOPE
B
132 kV S/W BUILDING
BARRIER
No. 2
SR1
SR2
CAP.
BANK
CAP.
BANK
BUFFER
ZONE
3m. W. CABLE RESERVE.
ACCESS ROAD
ROAD A8
BUFFER
ZONE.
BUFFER
ZONE
EXISTING
WOODLAND
AND SHRINE
CABLE RESERVE
B
C
P3
DRAINAGE RESERVE

FIGURE 4



SITE DIMENSIONS

SIDE	DISTANCE IN METRES
AB	84
BC	6
CD	40
DE	77
EF	30
FG	14
GH	76
HI	13
IJ	18
JA	56

BUILDING HEIGHT

BUILDING	DESCRIPTION	HEIGHT (IN METRE)	GROUND LEVEL AT P.D. (IN METRE)
A	400kV SWITCH HOUSE	29	20
B	132kV SWITCH HOUSE	15	16
C	FUTURE BLOCK	20	18

PRELIMINARY

CHINA LIGHT & POWER CO., LTD.

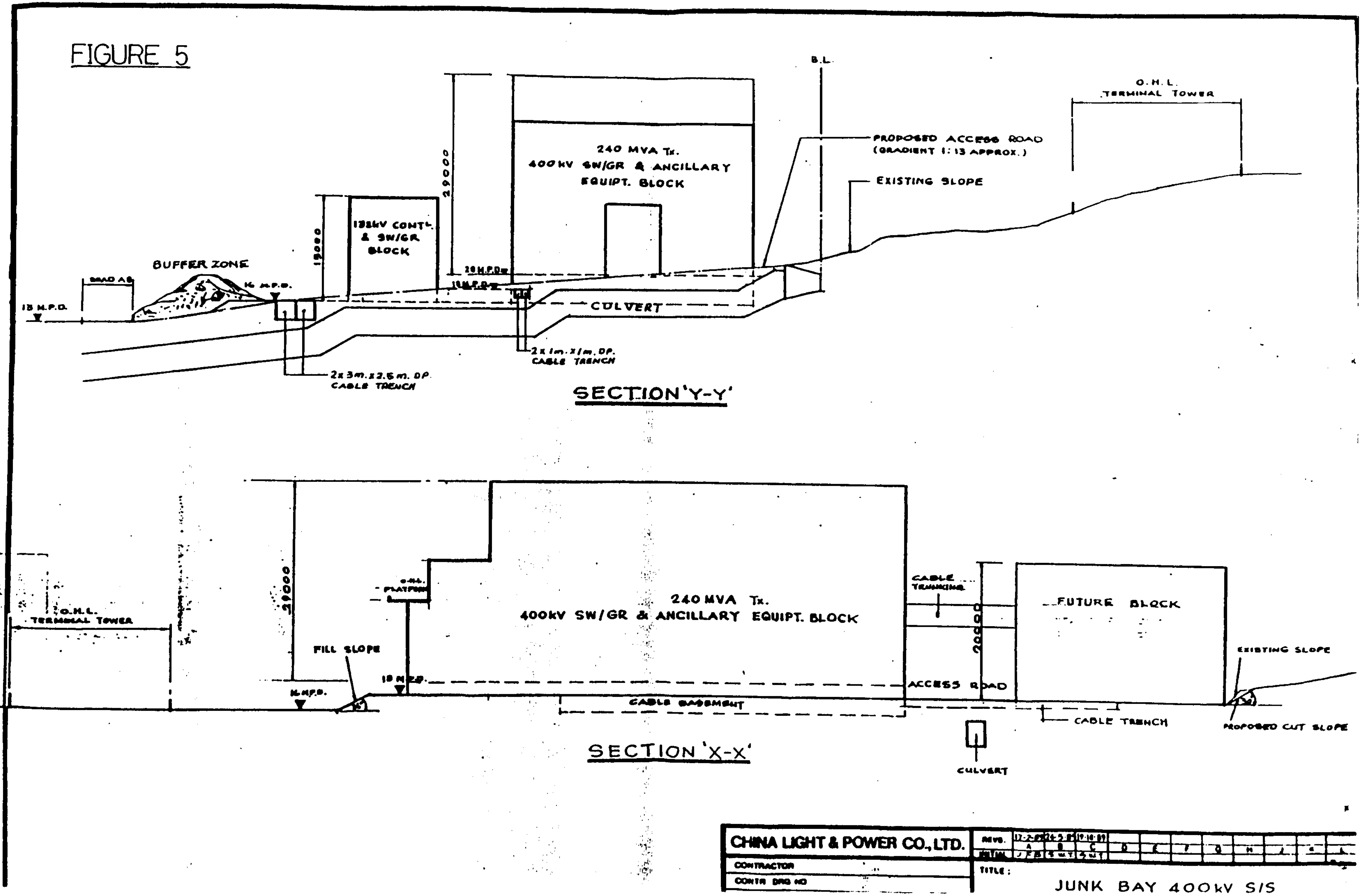
CONTRACTOR

CONTR. DRG NO

REVS. 24-5-89 | 20-10-89 — A | B — INITIAL S.W.T. | S.W.T.

TITLE: JUNK BAY 400kV SUBSTATION

FIGURE 5



B.L.
O.H.L. TERMINAL TOWER
PROPOSED ACCESS ROAD (GRADIENT 1:13 APPROX.)
EXISTING SLOPE
240 MVA Tx.
400kV SW/GR & ANCILLARY EQUIPT. BLOCK
29000
19000
132kV CONTL. & SW/GR BLOCK
BUFFER ZONE
13 M.P.D.
16 M.P.D.
CULVERT
2x1m.x1m. DP. CABLE TRENCH
2x3m.x2.5m. DP. CABLE TRENCH
SECTION 'Y-Y'
O.H.L. TERMINAL TOWER
29000
FILL SLOPE
16 M.P.D.
18 M.P.D.
240 MVA Tx.
400kV SW/GR & ANCILLARY EQUIPT. BLOCK
CABLE TRUNKING
20000
FUTURE BLOCK
EXISTING SLOPE
ACCESS ROAD
CABLE BASEMENT
CABLE TRENCH
PROPOSED CUT SLOPE
CULVERT
SECTION 'X-X'
CHINA LIGHT & POWER CO., LTD.
CONTRACTOR
CONTR DRG NO
TITLE:
JUNK BAY 400kV S/S

FIGURE 6

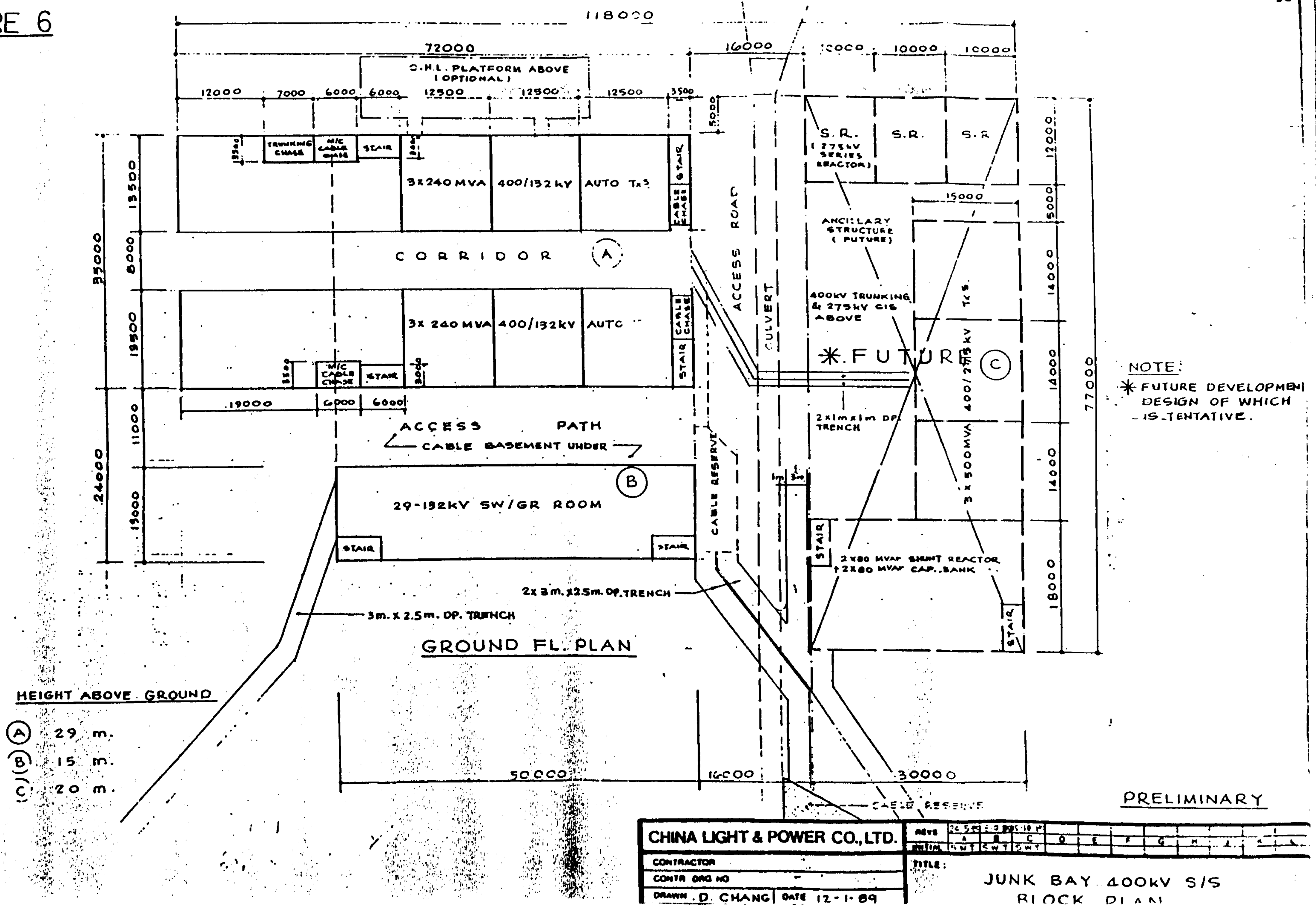
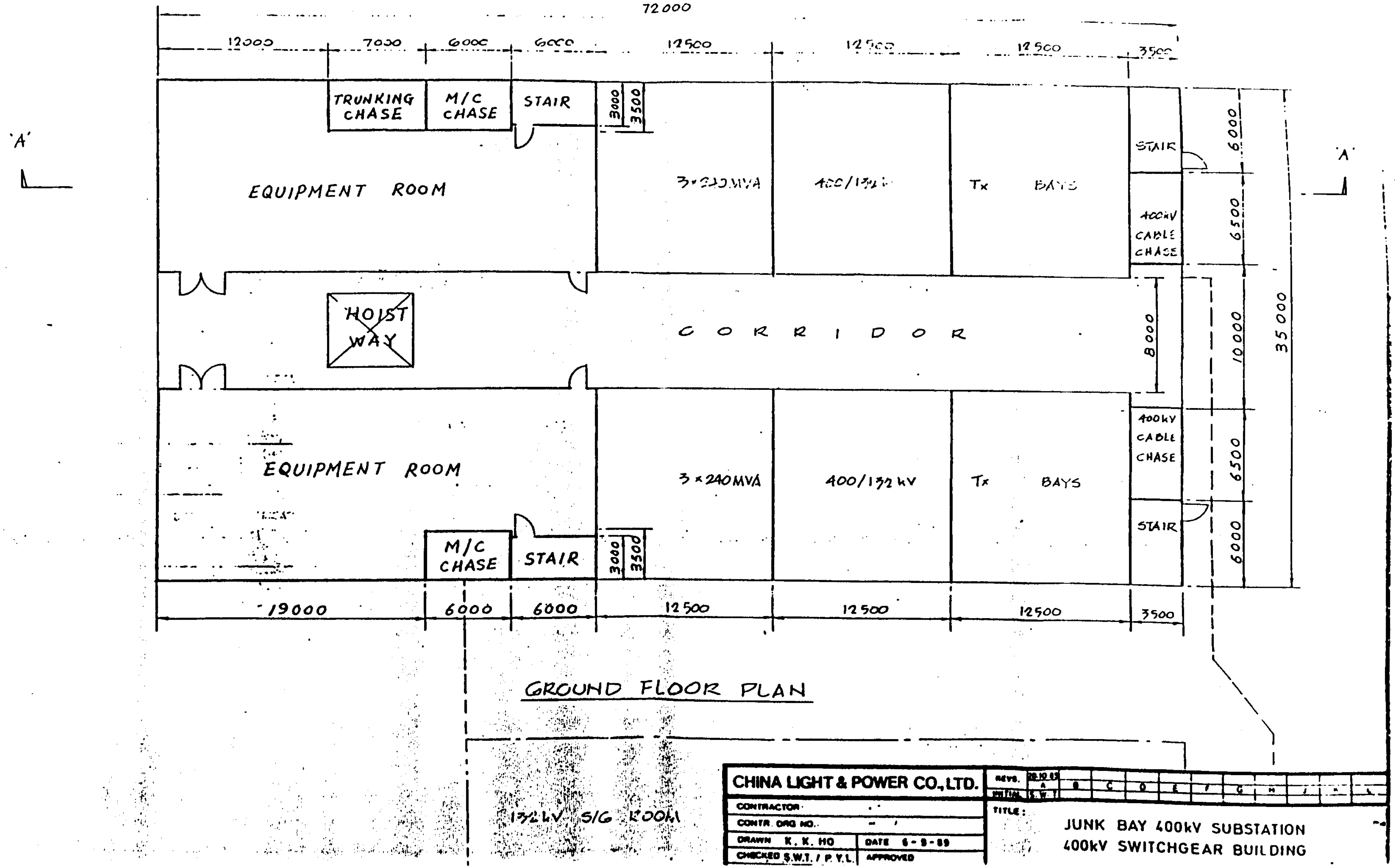

118000
72000
16000
10000
O.H.L. PLATFORM ABOVE (OPTIONAL)
12000
7000
6000
12500
3500
5000
TRUNKING CHASE
M/C CABLE CHASE
STAIR
3x240MVA
400/132kV
AUTO TxS
CABLE CHASE
CORRIDOR (A)
3x 240 MVA
AUTC
S.R. (275kV SERIES REACTOR)
S.R.
ANCILLARY STRUCTURE (FUTURE)
400kV TRUNKING & 275kV GIS ABOVE
✱ FUTURE (C)
3 x 500MVA 400/275kV TxS
2x1mx1m DP. TRENCH
2x80 MVAr SHUNT REACTOR + 2x80 MVAr CAP. BANK
ACCESS ROAD
CULVERT
35000
13500
8000
11000
24000
19000
14000
18000
15000
77000
ACCESS PATH
CABLE BASEMENT UNDER
29-132kV SW/GR ROOM (B)
CABLE RESERVE
2x 3m. x2.5m. DP. TRENCH
3m. x 2.5m. DP. TRENCH
GROUND FL. PLAN
50000
30000
NOTE:
✱ FUTURE DEVELOPMENT DESIGN OF WHICH IS TENTATIVE.
HEIGHT ABOVE GROUND
(A) 29 m.
(B) 15 m.
(C) 20 m.
PRELIMINARY
CHINA LIGHT & POWER CO., LTD.
CONTRACTOR
CONTR DRG NO
DRAWN D. CHANG
DATE 12-1-89
REVS
INITIAL
TITLE:
JUNK BAY 400kV S/S BLOCK PLAN

FIGURE 7



72000
12000
7000
6000
6000
12500
12500
12500
3500
'A'
TRUNKING CHASE
M/C CHASE
STAIR
3000
3500
EQUIPMENT ROOM
STAIR
400kV CABLE CHASE
6000
6500
10000
35000
8000
HOIST WAY
CORRIDOR
400kV CABLE CHASE
EQUIPMENT ROOM
3×240MVA
400/132kV
Tx BAYS
M/C CHASE
STAIR
19000
6000
6000
12500
12500
12500
3500
GROUND FLOOR PLAN
132kV S/G ROOM
CHINA LIGHT & POWER CO.,LTD.
CONTRACTOR
CONTR. DRG NO.
DRAWN K. K. HO
DATE 6-9-89
CHECKED S.W.T. / P.Y.L.
APPROVED
REVS.
INITIAL
TITLE:
JUNK BAY 400kV SUBSTATION
400kV SWITCHGEAR BUILDING

CHINA LIGHT AND POWER COMPANY LIMITED

Scientific and Technical Services Department

Scientific Services Branch

SUPPLEMENTARY REPORT ON THE NOISE IMPACT OF THE PROPOSED TSEUNG KWAN O EHV SUBSTATION

Report No. : SSB/ES/R134-90

Date of issue : December 1990

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Dr. A. Ashton - Actg. Scientific Services Office
Mr. B. Manifold - Snr. Environmental Officer

External : Environmental Protection Department, H.K. Govt.

CLASSIFICATION : UNRESTRICTED

Supplementary Report On the Noise Impact of the Proposed Tseung Kwan O EHV Substation

SUMMARY

In an attempt to examine the substation noise impact in more detail, this report has been written to provide fuller coverage on a number of issues. In this respect, it should be read in conjunction with Report No. SSB/ES/R122-90 (Ref. 1).

A further field measurement conducted at a specific location suggested by the Government Environmental Protection Department has indicated a small rise in noise levels as a result of a temporal change in the pre-existing local background noise climate.

With a view to preventing future noise nuisance and allowing the Company flexibility in meeting realistic noise limits, an approach using Background Noise Level +5 dB(A) has been adopted for this noise planning application.

On the basis of a comparison of the established noise limits with the predicted values, a noise nuisance is not anticipated at the nearest planned residential developments by utilising the noise control measures stated in the original impact report.

Approved for issue

Dr. A. Ashton
Acting Scientific Services Officer

INTRODUCTION

The noise impact assessment report (Ref. 1) produced for China Light & Power's Tseung Kwan O 400kV substation has been submitted to the Working Group of the Substation Project for consideration. The report concluded that a noise nuisance is not expected with regard to residents of the existing housing structures and future planned noise sensitive developments as indicated in the recent Government Development Plan provided that the recommended noise control measures are incorporated into the substation design.

According to the Project Plan, the substation will need to be commissioned in 1996. Thus it is essential to expedite progress on this project in order to ensure the future electricity supplies in the region.

Following a meeting with officials of the Environmental Protection Department (EPD), further details were required to support the noise prediction exercise and the establishment and compliance with suitable noise criteria. Thus at the request of the EPD (Ref.2), this noise impact report of the substation has been prepared with the objective of providing further coverage and elucidation of the following :-

1) To assess the noise levels at a specific location suggested by the EPD.

2) To elaborate the prediction methodology.

3) To suggest realistic noise criteria for the planning application.

4) To provide more information on noise control measures.

This report addresses the above issues and re-evaluates the potential for noise disturbance from the substation.

Evaluation of Noise Levels at a Specific Location

A sampling point marked P_2 in Figure 1 was further chosen for determining the pre-existing background noise levels. Measurements of the statistical indices L_1, L_{10}, L_{50}, L_{90}, L_{99} and L_{eq} were made concurrently on an hourly basis by using a Noise Level Analyser B&K 4426 coupled with a condenser microphone Type 4165. The measurement exercise was conducted in accordance with procedures detailed in the Technical Memorandum (Ref.3) and covered the time period from 23:00 to 03:00 hours on 7th November 1990. The results are presented as below :-

Table 1

Time Period	Noise Level dB(A) L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
23:00 - 24:00	39.5	41.0	43.5	46.5	51.5	46.7
00:00 - 01:00	40.5	41.5	43.0	45.5	53.5	44.8
01:00 - 02:00	39.5	41.0	43.0	45.5	52.5	44.4
02:00 - 03:00	40.5	41.5	43.5	45.5	49.0	44.1

The lowest L_{90} and L_{eq} levels recorded were 41.0 and 44.1 dB(A) respectively for a typical late night and early morning period. The results have clearly reflected the stable and consistent background noise climate in the neighbourhood of the proposed substation site. The change in noise minima is partly attributable to the temporal increase in traffic density along Roads D5, D2 and A8, human activities, insects, dog barkings and partly the measurement location which to a certain extent introduced the Facade Effect. Hence, the fluctuations are acceptable when compared with the previous noise minima of 38.0 dB(A) during the similar period of measurement time as indicated in the original impact report.

Elaboration of the Predicted Noise Levels

As stated in the original impact report, the substation will house 6 x 400kV transformers, arranged in two parallel rows of three on the north and south sides of the substation building 'A'. In the original report, the IEC 551 type test results (see appendix A) were used as the basis for assessment with noise level of 64. dB(A) at 2m for ONAF mode (tank plus cooler) and 67.5 dB(A) at 0.3m for ONAN mode. Since the transformers will all closely lie on the same plane, they can be viewed as a closely packed single noise source at distances reasonably far away. Hence, it can be calculated that the single source noise level will be 75.3 dB(A) and 71.9 dB(A) for ONAN and ONAF modes respectively.

In addition to the transformers, the substation will house two Shunt Reactors, between the substation building 'C' and the Capacitor Bank Building, which have a contract noise specification of 72 dB(A). However, the Company has decided to procure an enclosure type reactor of contract noise specification of 60 dB(A) in order to further minimise the impact from the substation.

In evaluating the noise levels at the facade of noise sensitive receptors, it is well understood that the noise propagating through the atmosphere decreases in strength with increasing distance. This attenuation is the result of several mechanisms namely,

a) geometrical divergence from the source,
b) absorption of acoustic energy by the atmosphere and
c) ground effect.

Amongst these mechanisms the source divergence is the most significant at the distances of concern. Thus the complex problem is highly simplified and approximated by the application of the following equation :-

$$L_p = L_{ref} - 20\log\left(\frac{d}{D_{ref}}\right) \text{ dB(A)}$$

where L_{ref} = reference L_p, in dB(A)

d = source - receiver distance, in metre

D_{ref} = reference distance, in metre

Lp = calculated noise level in dB(A)

For ease of reference, the data quoted in the original impac report are tabulated again as below :-

Table 2 : Basic Noise Data

Plant	Mode of Operation	Ref. Distance (m)	Ref. Level dB(A)
Transformer	ONAN ONAF	5.2 9.9	67.5 64.1
Shunt Reactor (with Noise Enclosure)	Continuous	6.3 (6.2)	72.0 (60.0)

Table 3 : Slant Distances from Substation to Prediction Points

Prediction Point	From Centre of Building 'A' (m)	From Centre of Shunt Reactors (m)
P_1	91	156
P_2	210	235
P_3	120	105
B	110	70
C	130	65

For convenience, contribution of plant noise at locations P_1, P_2 P_3, B & C are elaborated and tabulated as follows :-

Table 4 : Transformer ONAF Mode

	P_1	P_2	P_3	B	C
6 x Transformer at 2m	71.9	71.9	71.9	71.9	71.9
distance attenuation	-19.3	-26.5	-21.7	-21	-22.4
screening by Building 'B'	0	-3	-15	-3	0
Bay Partition attenuation	-15	-15	-15	-15	-15
Resultant Noise Level dB(A)	37.6	27.4	20.2	32.9	34.5

Table 5 : Transformer ONAN Mode

	P_1	P_2	P_3	B	C
6 x Transformer at 0.3m	75.3	75.3	75.3	75.3	75.3
distance attenuation	-24.8	-32.1	-27.3	-26.51	-27.9
screening by Building 'B'	0	-3	-15	-3	0
Bay Partition attenuation	-15	-15	-15	-15	-15
Resultant Noise Level dB(A)	35.5	25.2	18.0	30.8	32.4

Table 6 : Shunt Reactor Continuous Mode

	P_1	P_2	P_3	B	C
2 x Shunt Reactor (Low Noise Type)	63.0	63.0	63.0	63.0	63.0
distance attenuation	-28.1	-31.6	-24.6	-21.1	-20.4
Barrier attenuation	-10.0	-10.0	-10.0	-10.0	-10.0
Resultant Noise Level dB(A)	24.9	31.4	23.4	26.9	32.6

Combining the above noise levels of the transformers and the reactors, the following is obtained :-

Table 7

Prediction Point	Combined Noise Level dB(A) ONAN	ONAF
P_1	35.8	37.8
P_2	32.3	32.9
P_3	24.5	25.1
B	32.3	33.9
C	35.5	36.7

The above results represent the levels at the prediction points under free-field conditions and the absence of the transformer building structure. In practice, the layout of the substation with two parallel rows of 400kV transformer bays, should really mean that the noise levels from three transformers furthest from the receiving points P_2, P_3, B & C (or vice versa for P_1) will be shielded by the presence of the three transformers on the other side of the substation.

The acoustic screening effect of this shielding will indeed be limited due to presence of air gaps and it is difficult to predict the degree of noise reduction with certainty. However, with the gap surface area of circa 10 to 30% of the bay opening area, it would be conservative to say the noise energy contributed by the other three transformers be reduced by 10 to 30% as a result of such shielding. This corresponds to 1 to 3 dB(A) reduction of noise level at the prediction locations.

In order to account for the facade and tonality* effects, a factor of 6 dB(A),i.e. 3 dB(A) for each, will be added to each predicted level. Thus an addition of a factor of 5 dB(A) to each predicted level would be required if 1 dB(A) screening effect of the substation layout is taken into account.

If ONAN and ONAF modes correspond to night-time and daytime situations, the Corrected Noise Levels (CNLs) of Table 7 would become as the following :-

Table 8

Prediction Location	23:00 - 07:00 hrs CNL dB(A)	07:00 - 23:00 hrs CNL dB(A)
P_1	40.8	42.8
P_2	37.3	37.9
P_3	29.5	30.1
B	37.3	38.9
C	40.5	41.7

Establishment of Realistic Planning Noise Criteria

The Hong Kong Planning Standards and Guidelines (HKPS&G)(Ref. 4)recommended that intrusive noise levels should not exceed the existing background levels when measured at the facade of Noise Sensitive Uses.

The Environmental Protection Department (EPD) also has regard to the Planning criterion "Acceptable Noise Level - 5 dB(A)" (ANL-5) in assessing the acceptability of new noisy sources. Whilst the ANL-5 is a rigid ceiling figure, the use of background noise levels (BNL's) offers the opportunity to determine flexible limits based on specific " local circumstances ".

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* - See attached Transformer Manufacturer's type test report.

It is understood that the EPD will adopt either the BNL or the ANL-5 criteria whichever is the lower figure but that the EPD will consider each application on its merit and be flexible in deciding on the most suitable noise limit to be prescribed. It is suggested that any flexible approach should include consideration of variable criteria which can accommodate situation not only where no increase in the pre-existing background noise levels are permitted but also where a marginal or substantial increase could be permitted. Not increasing the background noise level is a very stringent and often onerous limit which is not always necessary where the noise climate is variable particularly during daytime periods. Situations where the Sensitive Area includes other sources of noise such as major roads and factories or where other developments are planned to take place in the same neighbourhood which will increase the noise climate in the near future, should be factors which require China Light and Power to consider when planning to construct a substation in the Area.

It has been demonstrated that a new noise level which is superimposed over a pre-existing background noise level by 10dB(A) will give rise to noise annoyance to a significant proportion of the community. However, a new noise source of +3 dB(A) above the background noise level is barely discernible. Planning control should seek to avoid noise annoyance from occurring and therefore for many situations, similar to that described in this report, the noise control requirement should realistically lie between BNL +3dB(A) and BNL +9 dB(A). This is particularly the case if the potentially intrusive noise must then pass through a partially opened window which would offer some additional attenuation.

By the above explanation, it is recommended that the planning noise criterion of BNL* +5 dB(A) for the worst case scenario be adopted in this case giving the substation noise limit of 43 dB(A) for nighttime situation ,i.e. 38 +5 dB(A),when measured at the facade of noise sensitive receptors. Likewise the daytime limit would be 55.1 dB(A).

In keeping with the current Government practice, the daytime noise limit would then become 55.0 dB(A) for the purpose of the assessment Noise Criteria (NC). Thus a comparison with the predicted levels indicates the following :-

Table 9

Prediction Point	23:00 - 07:00 hrs CNL dB(A)	23:00 - 07:00 hrs NC dB(A)	07:00 - 23:00 hrs CNL dB(A)	07:00 - 23:00 hrs NC dB(A)
P_1	40.8	43.0	42.8	55.0
P_2	37.3	43.0	37.9	55.0
P_3	29.5	43.0	30.1	55.0
B	37.3	43.0	38.9	55.0
C	40.5	43.0	41.7	55.0

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* - BNL refers to the lowest Background Noise Level as stated in the original report which is 38 dB(A).

Noise Control Measures

As stated in the original impact report, the proposed measures would provide the necessary noise reduction in the most practicable manner. These include the following :-

1) Erect acoustic partitions between the transformer tanks and the cooler units with an overall transmission loss of at least 15 dB(A). The transmission loss (TL) is a measure of sound insulation provided by the partition (sometimes it is referred to as the Sound Reduction Index). A typical partition material used by the Company has an average TL of 29.9 dB over the frequeny range of interest (See attached data sheet).

2) Erect masonry rigid/demountable walls of height 7.2m around the shunt reactors' boundaries (See Figure 1).

3) Install low noise cooler fans of broadband noise characteristics and weak emission strength (i.e. 47.4 dB(A) at 2m). The noise impact from these fans operation would be insignificant despite of their exposure to the atmosphere without any barrier shielding as this is supported by the case assessment conducted in the Yuen Long EHV substation.

4) Install enclosure type shunt reactors.

CONCLUSIONS

A further assessment of noise levels at a specific location suggested by the EPD has revealed a small increase in noise levels partly as a result of the temporal rise in other sources of background noise and partly the contribution of the facade effect.

In re-evaluating noise levels at some selected locations, the opportunity was also taken to suggest a fundamentally more realistic planning criterion which will prevent noise annoyance to the community but will also permit CLP flexibility to achieve the limit in a practicable manner since some known developments, as indicated in the Government Development Plan, will take place in the neighbourhood of the proposed substation which would very likely to raise the background noise climate . In this case, the night-time noise criterion of BNL +5 which equates to 43 dB(A) is recommended for adoption.

On the basis of the assessment, it is concluded that noise annoyance is unlikely to be experienced at the facade of present or future planned noise sensitive developments provided that noise control measures stated above are fully implemented.

RECOMMENDATIONS

1. A noise disturbance is not anticipated to arise at the facade o existing and future planned residential structures (See attache latest Government Development Plan) provided that noise contro measures stated in the original impact report are fully utilise and implemented.

2. It is understood that the noisy equipment will be installed a different stages of demand; it would seem a prudent approach t closely monitor the commissioned equipment and implement th control measures accordingly. Every effort will be made to comba the noise problem to ensure social acceptability of the substatio and noise nuisances will not arise.

REFERENCES

1. Noise Impact Assessment of the Tseung Kwan O EHV Substation Pre-commissioning Assessment (Author : Honry H.W. Cheng) Report No. : SSB/ES/R122-90

2. Government Planning Department's letter with attachment of the Environmental Protection Department's suggestions. Ref: (16) in SKT 3/12/2 dated 22nd September 1990

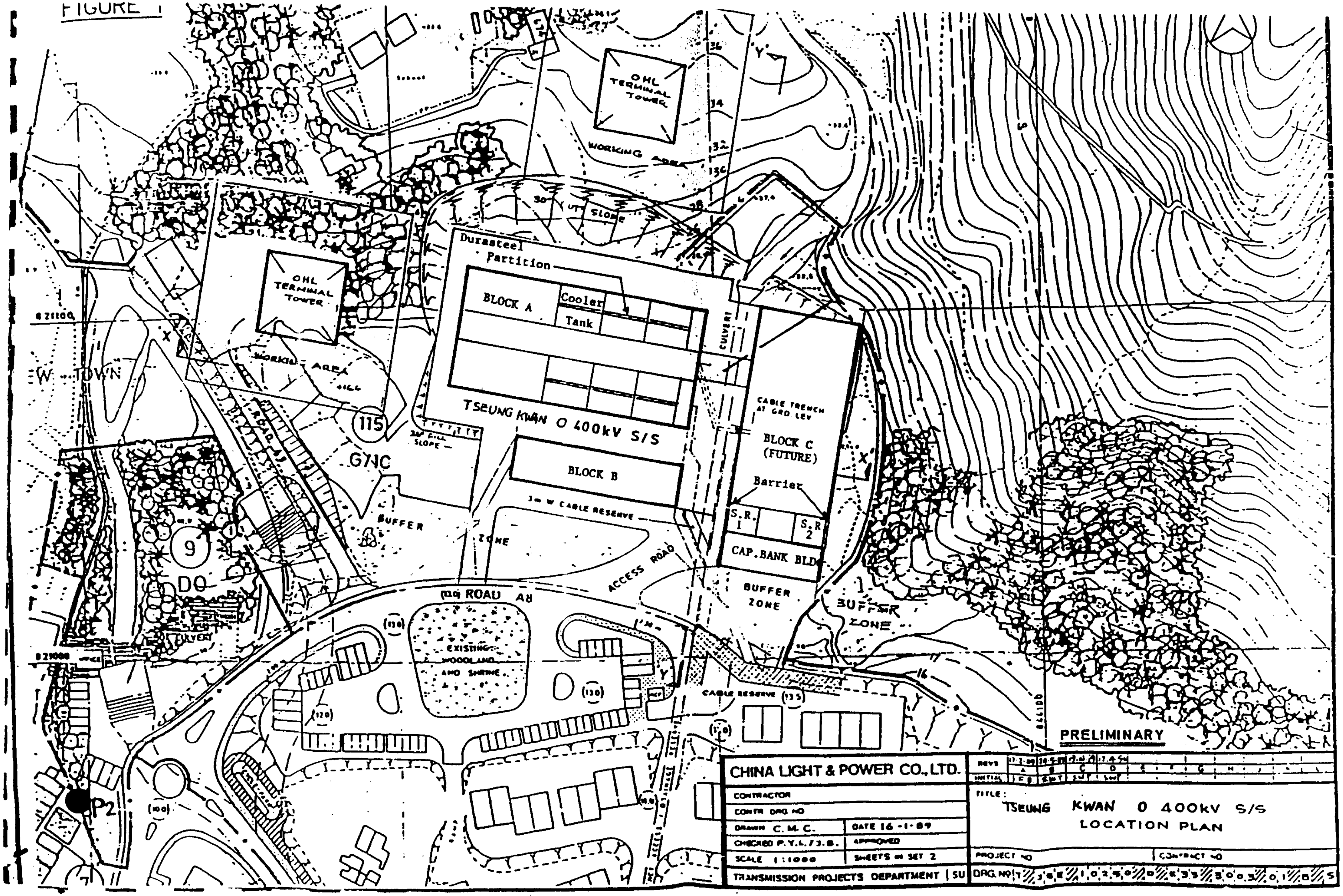
3. "Technical Memorandum for the assessment of Noise from Place other than Domestic Premises, Public Places or Construction Sites" -Special Supplement No.5 to the H.K. Government Gazette Extra-ordinary PE.157-167 (07.11.1988)

4. "Environmental Guidelines for Planning in Hong Kong" - An Extract from the Hong Kong Planning Standards & Guidelines Revised Chapter 9 - Environment (September 1990)

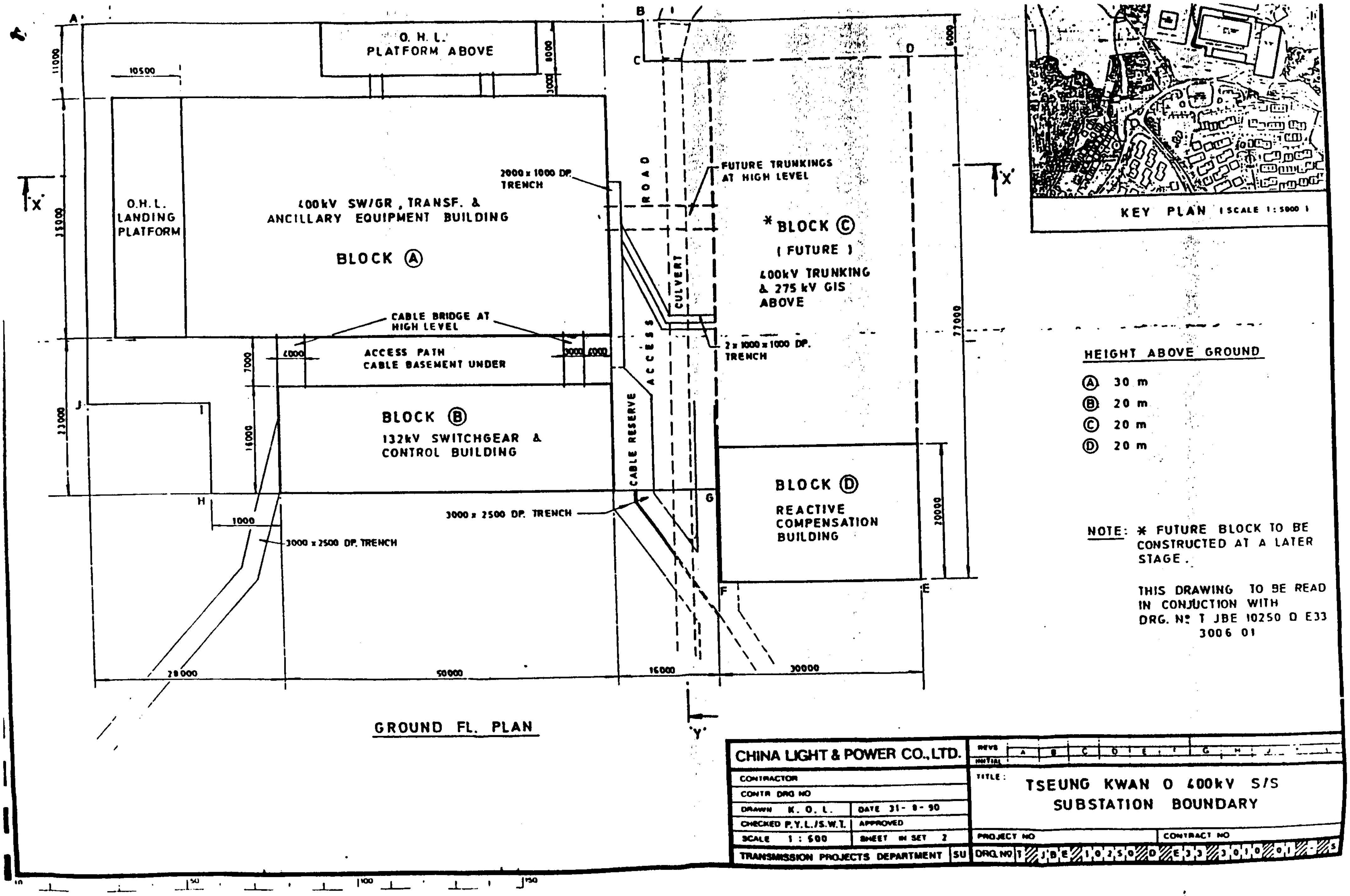
5. IEC Standard Publication 551 - "Determination of transformer an reactor sound levels" International Electrochemical Commission, Geneva (1987)

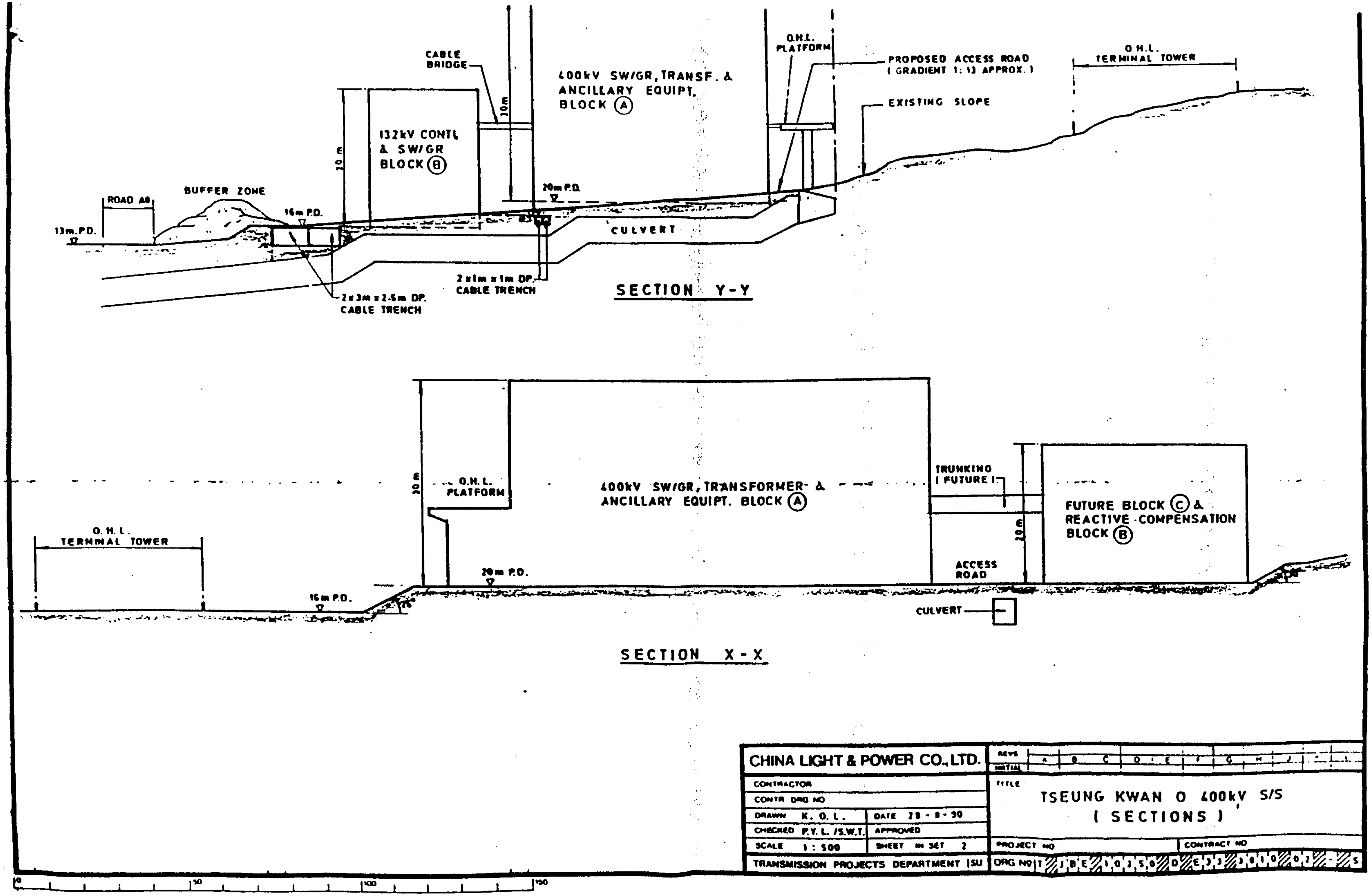
6. CEGB Design Memorandum 077/507 - "Suppression of Transforme Noise" by Central Electricity Generating Board, U.K. (1969)

FIGURE 1

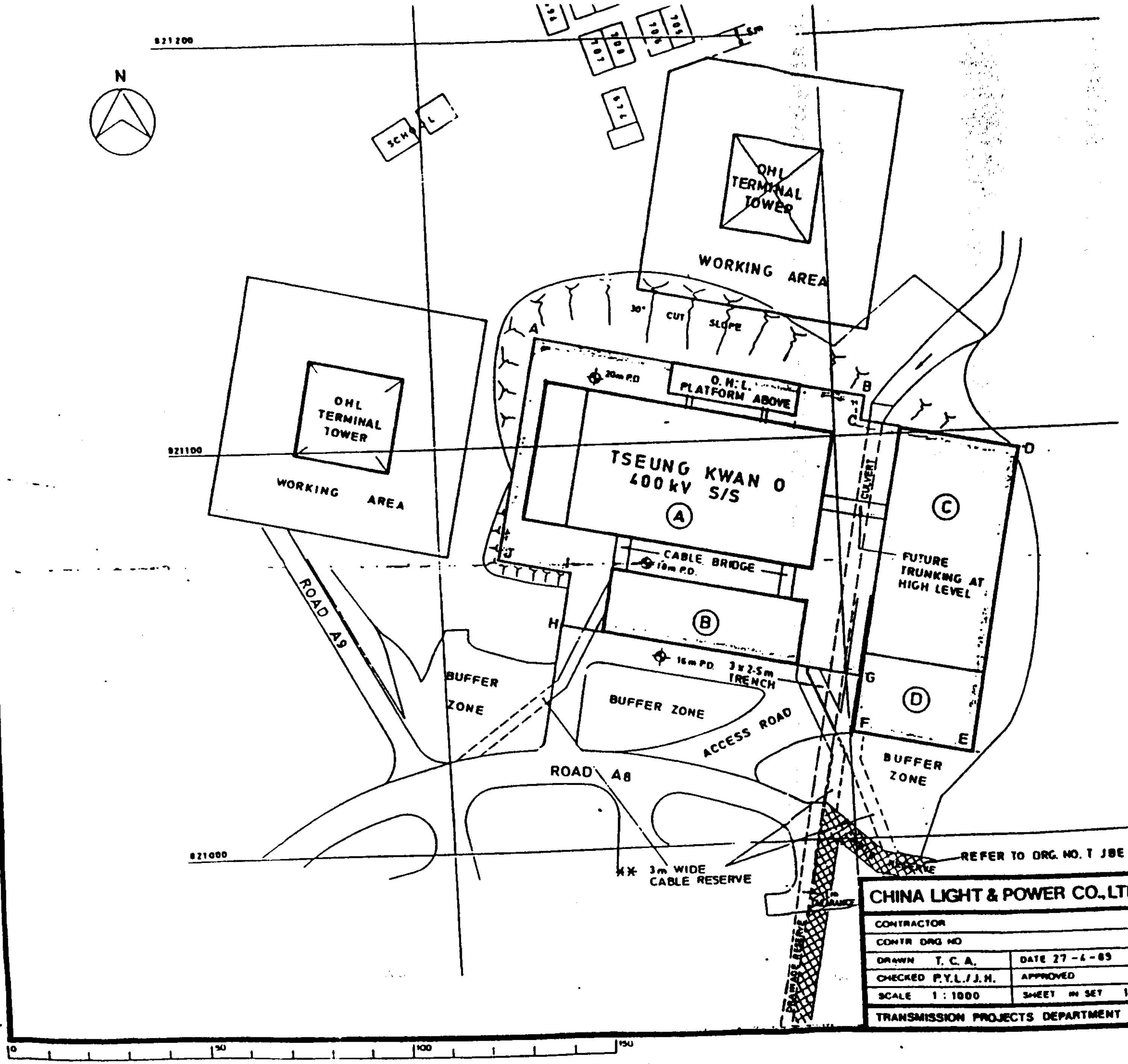


OHL TERMINAL TOWER
WORKING AREA
OHL TERMINAL TOWER
WORKING AREA
Durasteel Partition
BLOCK A
Cooler
Tank
CULVERT
TSEUNG KWAN O 400kV S/S
BLOCK B
CABLE TRENCH AT GRD. LEV
BLOCK C (FUTURE)
Barrier
S.R. 1
S.R. 2
CAP. BANK BLD
3m W CABLE RESERVE
BUFFER ZONE
BUFFER ZONE
BUFFER ZONE
ACCESS ROAD
ROAD A8
ROAD A3
EXISTING WOODLAND AND SHRINE
CABLE RESERVE
115
G/IC
9
DO
P2
PRELIMINARY
CHINA LIGHT & POWER CO., LTD.
CONTRACTOR
CONTR DRG NO
DRAWN C. M. C.
DATE 16-1-89
CHECKED P.Y.L./J.B.
APPROVED
SCALE 1:1000
SHEETS IN SET 2
TRANSMISSION PROJECTS DEPARTMENT
TITLE: TSEUNG KWAN O 400kV S/S LOCATION PLAN
PROJECT NO
CONTRACT NO


O.H.L.
PLATFORM ABOVE
O.H.L.
LANDING
PLATFORM
400kV SW/GR, TRANSF. &
ANCILLARY EQUIPMENT BUILDING
BLOCK Ⓐ
2000 x 1000 DP.
TRENCH
CABLE BRIDGE AT
HIGH LEVEL
ACCESS PATH
CABLE BASEMENT UNDER
BLOCK Ⓑ
132kV SWITCHGEAR &
CONTROL BUILDING
3000 x 2500 DP. TRENCH
3000 x 2500 DP. TRENCH
ROAD
CULVERT
ACCESS
CABLE RESERVE
FUTURE TRUNKINGS
AT HIGH LEVEL
* BLOCK Ⓒ
(FUTURE)
400kV TRUNKING
& 275 kV GIS
ABOVE
2 x 1000 x 1000 DP.
TRENCH
BLOCK Ⓓ
REACTIVE
COMPENSATION
BUILDING
11000
15000
23000
10500
8000
3000
5000
7000
4000
3000
3000
16000
1000
28000
50000
16000
30000
77000
20000
A
B
C
D
E
F
G
H
I
J
X
X'
Y'
GROUND FL. PLAN
KEY PLAN (SCALE 1:5000)
HEIGHT ABOVE GROUND
Ⓐ 30 m
Ⓑ 20 m
Ⓒ 20 m
Ⓓ 20 m
NOTE: * FUTURE BLOCK TO BE CONSTRUCTED AT A LATER STAGE.
THIS DRAWING TO BE READ IN CONJUCTION WITH DRG. No T JBE 10250 D E33 3006 01
CHINA LIGHT & POWER CO., LTD.
CONTRACTOR
CONTR DRG NO
DRAWN K. O. L.
DATE 31 - 8 - 90
CHECKED P.Y.L./S.W.T.
APPROVED
SCALE 1 : 500
SHEET IN SET 2
TRANSMISSION PROJECTS DEPARTMENT
SU
REVS
INITIAL
A B C D E F G H J
TITLE:
TSEUNG KWAN O 400kV S/S
SUBSTATION BOUNDARY
PROJECT NO
CONTRACT NO
DRG. NO T JBE 10250 D E33 3010 01 S
10 50 100 150



CHINA LIGHT & POWER CO., LTD.		REVS / INITIAL	A B C D E F G H J K L
CONTRACTOR		TITLE	TSEUNG KWAN O 400kV S/S (SECTIONS)
CONTR DRG NO			
DRAWN K. O. L.	DATE 28 - 8 - 90		
CHECKED P.Y. L. /S.W.T.	APPROVED		
SCALE 1 : 500	SHEET IN SET 2	PROJECT NO	CONTRACT NO
TRANSMISSION PROJECTS DEPARTMENT (SU		DRG NO 1 / J B E / 1 0 2 5 0 / 0 / E 3 3 / 3 0 1 0 / 0 2 / - / S	



REFER TO DRG. NO. T JBE 10250 D E33 8000 01

SITE DIMENSIONS

SIDE	DISTANCE IN METRES
AB	84
BC	6
CD	40
DE	77
EF	30
FG	14
GH	76
HI	13
IJ	18
JA	56

BUILDING HEIGHT

BUILDING	DESCRIPTION	HEIGHT (IN METRE)	GROUND LEVEL AT P.D. (IN METRE)
Ⓐ	400kV SWITCH HOUSE	30 *	20
Ⓑ	132kV SWITCH HOUSE	20 *	16
Ⓒ	FUTURE BLOCK	20	20
Ⓓ	REACTIVE COMPENSATION BLOCK	20	16

NOTE: * EXCLUDE WATER TANK OR MICROWAVE TOWER.

** EXACT ALIGNMENT TO BE DETERMINED LATER.

REVS	A	B	C	D	E	F	G	H	I	J
	24.5.89	20.10.89	10.11.89	27.4.90	28.9.90					
INITIAL	S.W.	S.W.Y.	S.W.Y.	S.W.Y.	S.W.Y.					

CHINA LIGHT & POWER CO., LTD.

CONTRACTOR	
CONTR DRG NO	
DRAWN T. C. A.	DATE 27-4-89
CHECKED P.Y.L./J.H.	APPROVED
SCALE 1 : 1000	SHEET IN SET 1
TRANSMISSION PROJECTS DEPARTMENT	

TITLE TSEUNG KWAN O 400kV S/S KEY PLAN WITH SUBSTATION BOUNDARY

PROJECT NO

CONTRACT NO

DRG. NO T JBE 10250 D E33 3006 01 E 5

TRANSFORMER TEST REPORT

APPL.

Audible sound level test — Serial No. 8817010101

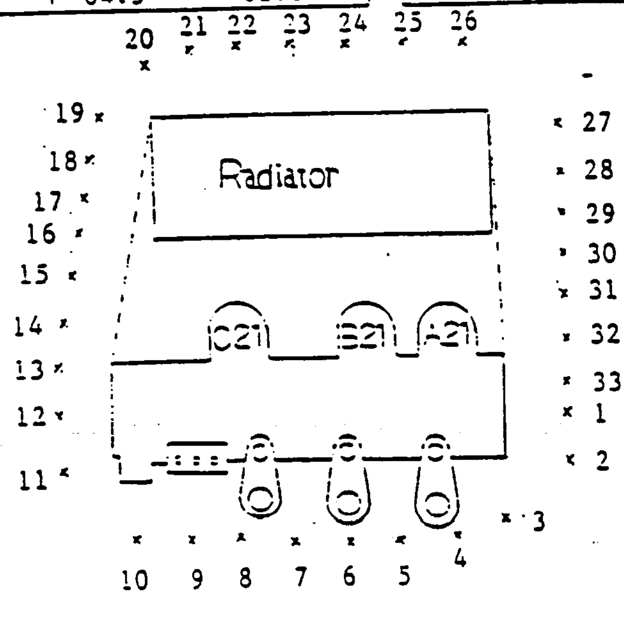
(by NA-09 type noise meter with A response curve)

The transformer was energized at rated voltage (400 kV) and frequency (50 Hz) with no load. (with sealing-off A - V pads)

The microphone was 2 m from any portion of the transformer radiators cooled by forc air in accordance with IEC 551.

Audible sound level : 64.1dB (correction 0.5 dB)

Location	Height 1/3 H	Height 2/3 H	Location	Height 1/3 H	Height 2/3 H	Location	Height 1/3 H	Height 2/3 H
1	63.0 dB	64.0 dB	14	61.5 dB	63.0 dB	27	65.0 dB	64.0 dB
2	64.5	65.5	15	65.5	63.0	28	66.5	66.0
3	67.5	62.0	16	67.0	63.0	29	65.5	65.5
4	66.0	67.0	17	61.0	64.0	30	65.5	64.0
5	68.0	65.0	18	62.0	65.5	31	63.0	63.0
6	71.0	66.0	19	65.0	61.5	32	63.0	63.5
7	70.0	63.5	20	60.5	60.5	33	65.0	64.0
8	64.0	64.5	21	65.0	61.5	34		
9	67.0	66.0	22	61.5	62.0	35		
10	66.5	62.5	23	63.0	63.0	36		
11	61.5	63.0	24	62.5	63.0	37		
12	61.5	61.0	25	63.0	61.0	38		
13	64.5	61.0	26	62.0	61.0	39		
						mean		64.6



Ambient sound level

= 55.5 dB

1	57.0
6	55.5
12	54.5
23	55.0

MITSUBISHI ELECTRIC CORP.,

TRANSFORMER TEST REPORT

APPENDIX A

Audible sound level test

Serial No. 8817010101

(by NA-09 type noise meter with A response curve)

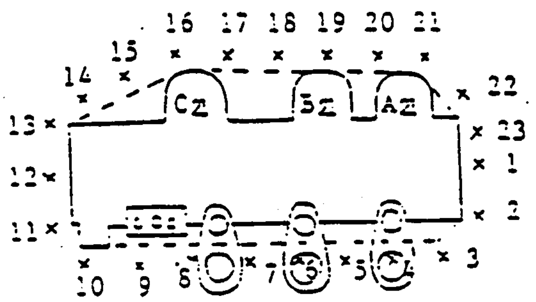
The transformer was energized at rated voltage (400 kV) and frequency (50 Hz with no load. (with sealing-off A-V pads)

The microphone was 0.3m from the major sound producing surface in accordance with IEC 551.

Audible sound level : 67.5 dB (correction : 0 dB)

Location	Height	
	1/3 H	2/3 H
1	67.0 dB	65.0 dB
2	64.5	67.0
3	66.5	66.0
4	69.0	65.0
5	71.5	70.0
6	69.0	69.0
7	72.5	68.5
8	66.5	66.0
9	66.0	66.5
10	63.5	65.5
11	64.5	62.0
12	63.0	61.5
13	63.5	62.0
14	67.0 dB	63.5 dB
15	68.0	65.0
16	69.0	67.0
17	72.0	68.0
18	70.0	71.0
19	72.0	65.0
20	68.0	66.5
21	66.5	67.5
22	64.0	65.0
23	65.5	64.0
24		
25		
26		
27	dB	dB
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
mean		67.5

Ambient sound level = 55.5 dB



MITSUBISHI ELECTRIC CORP., J.

Noise spectrum measurement (Ambient sound level)　　　Serial No. SS170?

Operating Condition ─┬ Transformer : Not energized
　　　　　　　　　　└ Cooler　　　: Not operated

1/3 octave-band center frequency (Hz)	Point No.	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5		
	Overall sound level dB(A)	56.0	55.0	57.0	55.5	54.5	51.0	51.0	52.0	50.5	50.5		
	25	15.0	—	14.0	14.0	14.0	13.0	—	11.0	12.0	15.0		
	31.5	20.0	13.0	19.0	18.0	18.0	18.0	13.0	18.0	18.0	18.0		
	40	19.0	17.0	20.0	20.0	19.0	21.0	18.0	18.0	17.0	23.0		
	50	29.0	25.0	23.0	24.0	24.0	32.0	25.0	26.0	26.0	24.0		
	63	35.0	28.0	29.0	28.0	28.0	30.0	30.0	32.0	33.0	31.0		
	80	30.0	28.0	30.0	28.0	30.0	27.0	30.0	28.0	28.0	29.0		
	100	33.0	32.0	33.0	34.0	32.0	35.0	31.0	32.0	32.0	32.0		
	125	36.0	34.0	[illegible]	35.0	35.0	36.0	33.0	34.0	35.0	35.0		
	160	38.0	38.0	41.0	39.0	38.0	37.0	36.0	39.0	38.0	37.0		
	200	41.0	39.0	40.0	39.0	39.0	38.0	38.0	40.0	38.0	38.0		
	250	42.0	43.0	44.0	43.0	42.0	41.0	42.0	41.0	40.0	42.0		
	315	45.0	47.0	48.0	47.0	46.0	40.0	40.0	43.0	40.0	40.0		
	400	44.0	46.0	48.0	46.0	45.0	40.0	41.0	45.0	40.0	41.0		
	500	44.0	44.0	48.0	44.0	45.0	41.0	39.0	41.0	40.0	42.0		
	630	46.0	46.0	48.0	46.0	46.0	39.0	39.0	41.0	40.0	40.0		
	800	46.0	46.0	48.0	47.0	45.0	41.0	40.0	40.0	40.0	41.0		
	1 k	45.0	46.0	49.0	47.0	46.0	39.0	38.0	41.0	40.0	40.0		
	1.25k	45.0	45.0	48.0	46.0	44.0	38.0	38.0	41.0	39.0	39.0		
	1.6 k	43.0	43.0	47.0	45.0	43.0	35.0	36.0	38.0	37.0	37.0		
	2 k	42.0	42.0	46.0	44.0	42.0	35.0	34.0	36.0	37.0	37.0		
	2.5 k	40.0	41.0	45.0	42.0	41.0	32.0	32.0	34.0	33.0	33.0		
	3.15k	39.0	37.0	42.0	40.0	39.0	32.0	30.0	33.0	32.0	33.0		
	4 k	37.0	34.0	38.0	38.0	36.0	30.0	26.0	30.0	30.0	32.0		
	5 k	32.0	31.0	34.0	34.0	33.0	27.0	24.0	26.0	27.0	29.0		
	6.3 k	27.0	26.0	28.0	28.0	27.0	22.0	20.0	22.0	22.0	23.0		
	8 k	20.0	20.0	20.0	20.0	19.0	16.0	15.0	15.0	15.0	16.0		
	10 k	15.0	14.0	15.0	15.0	15.0	13.0	10.0	10.0	12.0	12.0		
	12.5 k	14.0	10.0	11.0	13.0	13.0	13.0	—	—	11.0	11.0		
	16 k	14.0	—	—	12.0	12.0	13.0	—	—	10.0	10.0		
	20 k	14.0	—	—	12.0	12.0	13.0	—	—	10.0	10.0		

Noise spectrum measurement

Serial No. 88170

Operating Condition ┬ Transformer : No-load condition (with sealing-off A-V pads)
└ Cooler : Not operated

	Point No.	A1	A2	A3	A4	A5	B1	B2	B3	B4	C1	C2	C3	C4
Overall sound level dB(A)		58.0	61.0	61.0	66.0	67.0	56.5	59.0	61.0	62.5	62.0	57.0	61.0	66.5
1/3 octave-band center frequency (Hz)	25	14.0	—	—	—	20.0	15.0	—	—	—	—	11.0	—	—
	31.5	16.0	—	—	—	21.0	18.0	14.0	—	22.0	—	13.0	—	—
	40	22.0	—	22.0	21.0	22.0	22.0	16.0	20.0	24.0	21.0	16.0	20.0	23.0
	50	27.0	23.0	26.0	27.0	27.0	30.0	22.0	26.0	25.0	27.0	23.0	26.0	26.0
	63	33.0	27.0	29.0	30.0	27.0	30.0	26.0	28.0	26.0	30.0	26.0	30.0	28.0
	80	32.0	28.0	37.0	35.0	30.0	30.0	29.0	29.0	29.0	30.0	29.0	31.0	32.0
	100	39.0	37.0	48.0	48.0	34.0	37.0	40.0	33.0	33.0	34.0	38.0	42.0	46.0
	125	35.0	35.0	39.0	40.0	35.0	34.0	34.0	36.0	34.0	33.0	36.0	38.0	38.0
	160	40.0	39.0	42.0	44.0	40.0	38.0	36.0	39.0	40.0	38.0	37.0	42.0	39.0
	200	49.0	49.0	49.0	56.0	51.0	43.0	39.0	48.0	49.0	44.0	45.0	49.0	47.0
	250	43.0	45.0	46.0	50.0	44.0	44.0	40.0	47.0	42.0	43.0	42.0	45.0	50.0
	315	47.0	44.0	52.0	57.0	50.0	50.0	44.0	55.0	46.0	46.0	45.0	47.0	58.0
	400	46.0	46.0	50.0	55.0	50.0	45.0	45.0	53.0	48.0	48.0	45.0	51.0	50.0
	500	48.0	49.0	48.0	54.0	56.0	44.0	48.0	51.0	52.0	50.0	45.0	50.0	55.0
	630	51.0	58.0	50.0	63.0	65.0	45.0	56.0	53.0	59.0	59.0	51.0	54.0	64.0
	800	49.0	47.0	53.0	55.0	57.0	45.0	48.0	50.0	52.0	49.0	49.0	52.0	55.0
	1 k	46.0	46.0	51.0	55.0	54.0	47.0	46.0	51.0	49.0	48.0	47.0	53.0	52.0
	1.25k	44.0	45.0	49.0	51.0	51.0	44.0	44.0	48.0	48.0	45.0	44.0	47.0	48.0
	1.6 k	44.0	42.0	47.0	47.0	47.0	42.0	42.0	46.0	44.0	42.0	42.0	45.0	45.0
	2 k	42.0	40.0	44.0	43.0	44.0	41.0	40.0	44.0	42.0	40.0	40.0	44.0	42.0
	2.5 k	43.0	38.0	43.0	41.0	42.0	39.0	38.0	43.0	40.0	39.0	37.0	42.0	40.0
	3.15k	38.0	35.0	42.0	40.0	39.0	38.0	36.0	40.0	38.0	38.0	36.0	40.0	39.0
	4 k	35.0	32.0	37.0	37.0	36.0	35.0	32.0	36.0	35.0	36.0	32.0	37.0	36.0
	5 k	32.0	28.0	35.0	34.0	33.0	32.0	28.0	33.0	32.0	32.0	28.0	33.0	33.0
	6.3 k	28.0	25.0	32.0	29.0	27.0	27.0	25.0	29.0	27.0	28.0	25.0	30.0	27.0
	8 k	21.0	20.0	30.0	23.0	21.0	21.0	20.0	25.0	22.0	21.0	20.0	27.0	21.0
	10 k	16.0	—	26.0	—	—	17.0	—	20.0	—	—	—	23.0	—
	12.5 k	13.0	—	20.0	—	—	13.0	—	—	—	—	—	—	—
	16 k	12.0	—	—	—	—	12.0	—	—	—	—	—	—	—
	20 k	11.0	—	—	—	—	12.0	—	—	—	—	—	—	—

Noise spectrum measurement

Serial No. 88170101

Operating Condition — Transformer : No-load condition (with sealing-off A-V pads)
 └ Cooler : Operated

Point No.	A1	A2	A3	A4	A5	B1	B2	B3	B4	C1	C2	C3	C4
Overall sound level dB(A)	59.0	61.0	63.0	66.0	68.0	58.0	61.0	62.0	62.0	61.5	62.0	62.0	63.5
1/3 octave-band center frequency (Hz)													
25	16.0	—	—	—	20.0	14.0	—	—	—	—	—	—	—
31.5	24.0	24.0	20.0	20.0	21.0	18.0	—	—	22.0	—	—	—	21.0
40	24.0	26.0	22.0	23.0	22.0	24.0	22.0	23.0	23.0	24.0	20.0	23.0	22.0
50	32.0	29.0	28.0	30.0	29.0	29.0	26.0	29.0	24.0	29.0	26.0	30.0	28.0
63	35.0	32.0	32.0	32.0	30.0	31.0	29.0	32.0	31.0	30.0	32.0	32.0	31.0
80	33.0	34.0	38.0	36.0	31.0	33.0	33.0	34.0	32.0	31.0	33.0	34.0	34.0
100	43.0	41.0	49.0	49.0	36.0	39.0	42.0	38.0	37.0	39.0	41.0	42.0	45.0
125	38.0	41.0	42.0	41.0	37.0	38.0	40.0	39.0	37.0	38.0	42.0	40.0	39.0
160	41.0	44.0	43.0	45.0	41.0	41.0	42.0	41.0	41.0	41.0	43.0	42.0	41.0
200	50.0	47.0	49.0	57.0	51.0	50.0	42.0	46.0	50.0	50.0	46.0	46.0	50.0
250	45.0	46.0	47.0	49.0	46.0	46.0	43.0	47.0	44.0	45.0	45.0	45.0	47.0
315	49.0	47.0	56.0	54.0	48.0	49.0	46.0	54.0	48.0	46.0	48.0	48.0	55.0
400	47.0	48.0	54.0	55.0	50.0	48.0	47.0	52.0	49.0	47.0	47.0	48.0	49.0
500	48.0	49.0	51.0	54.0	56.0	46.0	52.0	51.0	51.0	52.0	49.0	51.0	51.0
630	52.0	57.0	53.0	63.0	67.0	49.0	58.0	53.0	58.0	59.0	57.0	56.0	58.0
800	50.0	50.0	54.0	57.0	58.0	47.0	50.0	52.0	51.0	49.0	50.0	54.0	55.0
1 k	48.0	49.0	52.0	55.0	54.0	46.0	47.0	50.0	50.0	48.0	50.0	53.0	54.0
1.25k	49.0	48.0	52.0	52.0	50.0	46.0	47.0	49.0	48.0	46.0	48.0	50.0	50.0
1.6 k	44.0	46.0	48.0	45.0	49.0	43.0	45.0	47.0	45.0	46.0	46.0	47.0	46.0
2 k	42.0	43.0	45.0	43.0	44.0	42.0	42.0	45.0	43.0	42.0	42.0	44.0	43.0
2.5 k	41.0	41.0	43.0	42.0	42.0	40.0	40.0	43.0	42.0	41.0	40.0	43.0	43.0
3.15k	40.0	38.0	41.0	40.0	41.0	38.0	38.0	41.0	39.0	40.0	38.0	41.0	40.0
4 k	37.0	35.0	40.0	38.0	37.0	36.0	35.0	38.0	37.0	37.0	35.0	38.0	37.0
5 k	34.0	33.0	38.0	35.0	34.0	34.0	32.0	35.0	36.0	34.0	33.0	35.0	34.0
6.3 k	30.0	32.0	34.0	30.0	29.0	30.0	29.0	32.0	32.0	31.0	31.0	33.0	29.0
8 k	25.0	28.0	33.0	25.0	24.0	24.0	26.0	28.0	25.0	26.0	27.0	30.0	23.0
10 k	19.0	24.0	27.0	21.0	—	18.0	21.0	23.0	—	—	22.0	26.0	—
12.5 k	14.0	—	23.0	—	—	13.0	—	—	—	—	—	20.0	—
16 k	12.0	—	—	—	—	11.0	—	—	—	—	—	—	—
20 k	11.0	—	—	—	—	11.0	—	—	—	—	—	—	—

T

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4.0 NOISE LEVEL MEASUREMENT

4.1 Measurements were to be made as illustrated in the works sketches, mentioned in paragraph 3.1.

4.2 Fan was set up in a vertical position and microphone position marked out at eight equally spaced positions around the unit. Readings were to be made first at a distance of one metre and secondly at two metres from the fan unit.

4.3 Background levels were first recorded and were seen to be of a moderate level, but the information was given that the factory is generally operating throughout the twenty-four hours per day during the working week and at no pre-determined time can quieter conditions be forecast (See paragraph 4.5).

4.4 Readings were taken at one metre and two metres from the fan unit and were computer calculated to give the corrected results:-

At 1 metre	-	53.4 dBA
At 2 metres	-	47.4 dBA
At 3 fan diameters (12 feet)	-	42.4 dBA

4.5 To obtain results of possibly greater accuracy the Laboratory Supervisor undertook to take further tests of the fan at a period when it was known that the factory and its associated foundry would not be operating. This was anticipated to be during a weekend that is associated with a National holiday.

4.5.1 These additional readings are included in this report but show little improvement in the sound level.

APPENDIX B

TESTED TO :- TEST SPECIFICATION DETAILED AS APPENDIX A   Lp @ 1 metre to fan

PROJECT No 6106   DATE:- 23rd JULY 1909

FAN DESCRIPTION 40J1/2 16 POLE 29° ,1D DB INLET AND 500mm BB OUTLET SILENCER + ANCILLARIE
Order No 162259/05X

TEST POSITION	OCTAVE BAND CENTRE FREQUENCY								TOTALS	
	63	125	250	500	1K	2K	4K	8K	LIN	A
1	63.5	57.2	57.0	49.1	44.9	40.6	35.8	31.1		
2	62.9	58.7	59.3	48.3	44.3	41.2	34.9	29.7		
3	61.3	59.5	58.3	49.9	43.6	39.3	33.4	28.7		
4	62.6	58.9	60.2	49.2	43.4	40.0	34.1	29.3		
5	62.5	58.0	62.4	50.6	44.6	40.8	35.2	30.7		
6	63.2	58.0	59.9	49.3	44.3	40.6	35.1	30.6		
7	65.2	58.0	58.7	50.0	44.9	40.6	36.0	30.0		
8	65.2	59.3	60.0	49.0	45.0	40.3	35.2	30.7		
Lp MEAN	63.5	58.5	59.7	49.6	44.4	40.5	35.0	30.2		
BGROUND	58.4	50.9	45.0	42.6	38.0	35.0	25.6	17.6		
CORRECTED Lp MEAN	61.9	57.7	59.6	48.6	43.3	39.0	34.5	29.9		
A WEIGHT Lp MEAN	35.9	41.2	51.1	45.6	43.3	40.0	35.5	28.4		53.4

dBA @ 2 METRES = 47.4

APPENDIX C

AIRO ACOUSTICAL INVESTIGATION & RESEARCH ORGANISATION LIMITED	DATA SHEET	
	DATE January, 1977.	No. L. 1427.

CLIENT DURASTEEL LTD.,

Measurements of the Sound Reduction Index of a 3000 x 3000 x 9.5 mm thick 3 DF2 partition.