OCCASION

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

DISCLAIMER

FAIR USE POLICY

CONTACT

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

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

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

RESTRICTED

DP/ID/SER.A/1405
25 October 1990
ORIGINAL: ENGLISH

18650

FEASIBILITY ANALYSIS UNIT FOR PRE-INVESTMENT STUDIES
(NATIONAL INVESTMENT BANK)

DP/GHA/87/026/11-61

GHANA

Technical report: Evaluation of potential of small and medium-scale projects for production of wires, cables and other telephone accessories for pre-feasibility studies*

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

Based on the work of N. Kumar Madampath, industrial engineer

Backstopping officer: U. Loeser, Feasibility Studies Branch

United Nations Industrial Development Organization
Vienna

* This document has not been edited.

V.90-88703

TABLE OF CONTENTS

SUPPORT TO FEASIBILITY ANALYSES UNIT FOR

PRE-INVESTMENT STUDIES FOR GOVERNMENT OF GHANA

AT THE NATIONAL INVESTMENT BANK THROUGH

UNITED NATIONS INDUSTRIAL DEVELOPMENT PROGRAM

NO. DP/GHA/87/026/11-61/J14102

FROM 23.8.90 TO 8.9.90 (AT ACCRA)

THIS REPORT IS PREPARED TO ENABLE THE GOVERNMENT

OF GHANA, THE NATIONAL INVESTMENT BANK AND OTHER

SPONSORS TO IDENTIFY NEW INVESTMENT PROJECTS AND THEIR

POTENTIAL AND PREPARE TECHNO-ECONOMIC FEASIBILITY STUDIES.

EXPERT ON MISSION -
MADAMBATH NANDAKUMAR NAYAR (M.N. KUMAR)

CHIEF TECHNICAL ADVISER - UNIDO-GHANA
DR. J.M.I. SAIT

HEAD OF PROJECTS DEPARTMENT - NIB-GHANA
MR. SAMUEL ASARE

PART I

SUMMARY

1. The project to decide implementation priorities in respect of establishment of small and medium-scale projects for production of wires and cables and other accessories for telephone industry in Ghana, was undertaken by Mr. N.K. Madambath, (Mr. M.N. Kumar) from 18.8.90 to 13.9.90.

2. Government of Ghana, has already a draftplan, for development of power generation and distribution on hand. About 30% increase in the near future is targetted.

3. Ghana, manufacture wires (House wiring), Low tension cables, and high tension over head wires. The major plant manufacturing these products, remains underutilised. It can improve utilisation by export of the above items, to neighbouring states, and diversification into manufacture of enamelled copper wires.

4. No incentive for the use of aluminium is found as the raw material prices of copper and aluminium are not much different. Both have to be paid in US$ only.

5. Diversification and better utilisation of existing factories in Ghana can be achieved if the manufacture of enamelled copper wire is undertaken by them. However they have not shown interest in the subject as they intend to concentrate on wire drawing and cable making.

6. Enamelled copper wires are being imported since long. The local market for this product is good. Value added in this product is quite high. Future requirement is on the increase. Ghana does not have the facility for making this product.

7. Installation of a unit in Ghana, for the manufacture of enamelled copper wire, is recommended. A prefeasibility report has been prepared accordingly.

Salient Features	(in ¢million)
Total Investment	227.11
Total Sales	453.60
Net Income	130.11
Foreign Exchange Earning	206.00
Internal Rate of Return	82.25%
Ratio of Raw Material Price to finished Product Price	1:2.97

8. Local enterpreneurs have shown interest in the above project.

9. Technology for the manufacture of enamelled copper wire is not available in Ghana and needs to be imported. Skilled workers required for the project can be trained from local labour force.

10. Acknowledgment:

The expert wishes to acknowledge with thanks the co-operation received from

Dr. J.M.I. Sait, Chief Technical Adviser, UNIDO

Mr. S. Asare, Head, Projects Department, National Inv. Bank, Accra

Messrs. Antti Ahonen, Carlsen and Tauchman, UNIDO Consultants

Officers of National Investment Bank, Accra and Kumasi for their valuable suggestions and assistance.

N.K. MADAMBATH

INTRODUCTION

1. As per the special service agreement - expert on Mission INDEX No. E620972, PPRD/APPINO 1513/901KS, a memorandum of understanding was signed among UNIDO and Madambath Nanda Kumar Nayar for a mission in Ghana, as per enclosed job description - Annexure 1. (Memorandum of understanding needs revision).
2. Reported to UNIDO Vienna on 20- 8-90 for briefing.
3. Left Vienna on 22.8.90 and reported at UNDP Ghana on 23.8.90 was briefed thoroughly by Dr. J.M.I. Sait (Chief Technical Adviser) UNIDO Ghana and Mr. S. Asare, Head of Projects Department, NIB Ghana.
4. The duration of the mission was intially lfrom 18-8-90 to 1-9-90 including days of travel, was subsequently revised to 13-9-90 to complete the work and also to participate in the technical session of the seminar conducted by NIB for two days.
5. The objectives of the mission is enclosed in Annexure 2.

CURRENT STATUS OF WIRE INDUSTRY IN GHANA

1. Ghana is currently producing electrical wires from copper. The wires are used for house-wiring and low tension cables for distribution purposes and high tension overhead wires. High Tension power cables are being imported as part of the aid programme for electrification. Aluminium wire is not being produced as the price of aluminium is practically the same as that of copper and both payable in US Dollars; presently there is no incentive to change over from Copper to Aluminium. The only producer of electrical wires KABLE METAL (GHANA) LTD., a joint venture between a private enterpreneur and the National Investment Bank, had plans, a decade ago to go into a program of manufacturing aluminium

rods by continuous casting as feed stock for their wire drawing facility. This was not followed up owing to price indifference between copper and aluminium.

This unit is under-utilised and is running only on one shift basis per day. If it starts exploring export market for home-wiring, insulated and low tension power cables, and telephone cables, the utilisation of the unit can be substantially improved. Since NIB is one of the promoters it can take the lead in exploring the foreign market through government to government level contact. A study at various African centres shall be helpful in exploring means of utilising the plant capacity to the maximum.

2. No other kind of wire is being produced in Ghana.

STATUS OF POWER GENERATION, DISTRIBUTION AND UTILISATION

3. According to Dr. CHARLES Y. WEREK-BROBBY, Energy policy Advisor to the Ministry of Fuel and Power,

   (a) A draft plan for the development of power generation and distribution for the next 30 years is already made. However, it will take about 3 months to finalise the same after which he shall be able to give the details. He has asked to get in touch with him after 3 months. (UNDP/NIB, Accra may collect this information at the appropriate time).

   (b) Power generation is expected to increase by 300 MW in the next couple of years, making the total production to 1400 MW. Distribution network will also increase as the government is considering the electrification of all districts.

   (c) A number of items which could be made in Ghana is being imported and that NIB and UNIDO, is going in the right direction, by

bringing in experts in the various fields to enable Ghana to manufacture goods locally, and that the visit of an expert in the electrical winding wire field is well timed.

4. The expert also visited the Kpong Hydro-electric station and had discussion with the Plant Manager where it was pointed out that it is proposed

   (a) to increase power generation capacity by 30% in the next couple of years;

   (b) to establish a power grid connecting Ivory Coast, Togo and Burkina Faso;

5. The requirement of power generation and distribution accessories will be on the increase in the coming years.

WINDING WIRES - A GOOD POSSIBILITY

6. POWER - A commodity that cannot be stored, needs facility for consumption along with generation. Power is consumed through static or rotating machinery. In both the cases, winding wires are used. Thus a good scope is seen now and in the years ahead for a unit for the manufacture of winding wires.

7. There are about 800 to 1,000 rewinders in Ghana out of which number about 400 are in and around Accra and Tema. They undertake rewinding of refrigeration compressor motors, fans, electric motors, car dynamos and starters, small transformers and small static machines. They buy the wires from merchants who import the same from Europe. The local price of the wire is based on the foreign exchange rate of cedi vis-a-vis the USDollar: According to the various motor winders and retailers/ wholesalers met, the average consumption per winder ranges from 15kgs. to 300kgs. per month. The prices range from ¢3,800 to ¢5,300 per kg.

8. To study the market conditions, out of the nine regions in Ghana visited Kumasi of the Ashanti Region. At Kumasi, many units are engaged in timber logging. Different types of motors are being used in these units. Visited two major units and it is understood that they are rewinding the motors locally and that they are importing the enamelled wires from Europe. It was however said that the local utilisation of timber in furniture ect., production has not kept up with expectations and that they were in financial problems. Situation is improving and that they shall be going ahead with diversification and expansion in the near future. Also visited Asante Goldmines Limited and discussed with Local Purchase Manager the requirements of various gauges of enamel copper wire used by them for rewinding the motors locally.

9. The overall consumption based on the above information is estimated to be about 15MTS. to 100MTS. per month. In view of this it appears that a monthly consumption of about 25 to 40 metric tonnes per month is a realistic estimate. The consumption will increase with the increase in power generation and distribution and also with the local availability of the wire. Sale of electrical machines, motor cars, refrigerators, airconditioners etc. which is already showing an upward trend will increase the work load on rewinders. In view of this it is felt that a winding wire unit suitable for making the product for the above requirement is ideal for Ghana.

LOCAL SPONSORS

10. Met some of the top industrialists/traders in Ghana who are capable and interested in investment. Among them Mr. Amar, Managing Director, Brac Bury showed keen interest in the proposal. The KABEL METAL (GHANA) LTD.

expressed that they would not be interested in diversifying production as they would like to concentrate on strengthening their existing business. A feasibility report was prepared based on COMFAR - UNIDO system, and a joint meeting with the party and UNIDO Chief Technical Adviser, Dr. Sait was arranged. Party has asked for time to study the proposal. UNIDO/NIB can follow up the proposal.

THE PROJECT PROFILE

11. Messrs. KABEL METAL (GHANA) LTD. have surplus capacity for wire drawing but are not interested in enamelling operations. The entrepreneurs who were interested in the Project were interested in an exclusive and comprehensive unit and were not keen on tying up with a single supplier. In view of this situation a prefeasibility study was conducted for a wholesome Project to manufacture 15MT P.M of enamelled copper wire and the resultant Project Profile and the schedules prepared using UNIDO-COMFAR are enclosed as Annexure 2.

12. The salient facts emerging out of the study are summarised below.

Total investment cost	¢227.11 million
Total sale value	¢453.60 million
Total direct costs	¢215.011 million
Opg. Margin	¢165.686 million
Interest charges	¢ 35.573 million
Other fixed costs	¢ 72.903 million
Net Profit	¢130.113 million
Return on Investment	69.72%
Return on sales	28.684%
Tentative I.R.R.	82.25%
Breakeven Point	30.5%
Payback period.	2 years

PRODUCT STANDARDS

13. Ghana Standard Board is yet to make the standard specifications for copper wires, aluminium wire and winding wires. A set of standards according to Indian Standard Specifications (ISS) are attached in Annexure 3.

CONCLUSION AND FINDINGS

14. (a) There is no unit in Ghana for the manufacture of enamel copper wires;

    (b) From the restricted market survey consumption is estimated at 15 to 100mts. per month.

    (c) The value added in the enamalled copper wire is quite substantial and the unit for the manufacture of this product is viable;

    (d) The unit will save foreign exchange and also shall be able to export the product.

    (e) In view of the above, it is observed that a winding wire unit for the manufacture of enamel copper wire would be a desirable industry for Ghana.

15. The capacity of the unit is restricted to 15mts. per month to be on the safer side. Further this capacity can be increased to three times by minor increase in the machinery.

16. Messrs. KABEL METAL (GHANA) LIMITED has the wire drawing machinery available with them, and underutilised. These machines can be used for the manufacture of enamel copper wire by the addition of enamelling machines. Alternatively they could supply wires to a new unit for enamelling.

RECOMMENDATIONS

1. NIB, being a shareholder of the Kabel Metal (Ghana) Ltd., should first consult the Board of Directors of the company to ensure their stand on the diversification of the product line into enamelled winding wires.
2. Thereafter, a detailed feasibility study should be conducted to develop the present study into an implementation programme to suit the requirement of the ultimate sponsor, i.e. for expansion with an enamelling unit for Kablemetal or for a composite unit for other interested parties. This study should incorporate detailed market information relevant to consumption of wire in Ghana as well as the other ECOWAS countries.

PART II

PROJECT PROFILE
MANUFACTURE OF ENAMELLED WIRES

The economy of Ghana, which received a severe setback from 1975 to 1983, has revived since then. During this period, most of the industries produced far below their capacity and some even closed down. The gross domestic product which declined to 2.9% in 1983, recorded an 8.6% growth in 1984, 5.1% in 1985 and 5.3% in 1986. (Ref. Handbook of Commerce and Industry prepared by Ministry of Trade and Tourism). Consequent to the revival of economy, industrialisation and power consumption are expected to increase. Power being a vital commodity, any industrial product connected with power also play an important role.

2. There are about 800 to 1,000 rewinders in Ghana, rewinding

(a) Electric motors;
(b) Transformers - small;
(c) Refrigeration compressors;
(d) Other static electrical appliances.

The annual consumption ranges from 160 to 480MT on a rough and ready basis.

Today, Ghana imports enamelled copper wire from Europe. Since the Government of Ghana propose to increase the generation and distribution by approximately 30%, the consumption of enamelled copper wires will also increase in the coming years. Also there will be increase in the distribution transformers and other generation and distribution equipment. It is also informed that a foundry is being rejuvenated through UNIDO at Tema. If this foundry can be used for the manufacture of castings for electrical motors at a later date, motors can also be manufactured as the vital raw material that is enamelled copper wire might have come into stream by then.

3. Having established the need for an enamelled copper wire industry in particular and winding wire industry in general, this pre-feasibility report is prepared. This will be a PIONEER INDUSTRY in Ghana, and it will be in the core sector - i.e. associated with distribution and consumption of power. Since the value added is high, a ratio of raw material to finished product price is approximately 1:2.97, this unit will save substantial foreign exchange for Ghana, and will not face significant competition from imported enamelled copper wire. In the event of this unit coming up, other industries, such as electric motors, transformers (small), miniature motors, automobile accessories etc. can be established at a fut re date as copper wire forms a basic raw material.

GENERAL DESCRIPTION OF THE PROJECT

4. The Project is primarily designed to produce 15MT per month of enamelled copper wire suitable for rewinding electric motors, compressor motors, small transformers and other electrical appliances. The unit will have capability to produce over-coat wire, subject to the presence of demand. The product range will cover SWG 15 to SWG 24 wires corresponding to Indian Standard Specification ISS 4800 Parts I and II coated with various types of enamels such as:

Polyvynye Acetyl
Modified Polyester
Hermetic grade PVA
Hermatic polyesterimide, described in

detail in the attached standard specification (ISS 4800). Part I to Part IX.

By adding certain machines, the unit can also be used for the manufacture of

(a) enamelled fine and superfine copper wires,
(b) paper covered round wires,
(c) cotton covered round wires,
(d) enamelled paper covered round wires,
(e) enamelled fiberglass covered round wires,
(f) tinned copper wire and fuses,
(g) paper covered rectangular conductors

With minor modification in the machines, the unit can be used for the manufacture of aluminium enamelled wires, also.

PRODUCT USES

5. Product can be used in

(a) electric motors
(b) refrigeration/airconditioner compressor motors
(c) electric fan motors
(d) small transformers
(e) car dynamos and starters
(f) electrical instruments
(g) telephone equipments

THE MARKET

6. A quick study revealed that the present demand for winding wires of all specifications ranges from 15mts to 45mts per month, which will increase progressively. But it is necessary to carry out a detailed market study at the appropriate time.

7. As the enamelling technology has already stabilised to a great extent the product quality will be as good as the imported ones and will be readily accepted by the market. No marketing problems are envisaged.

COMPETITION

8. The product will initially have to compete with imported product. However since the quality would be as good as the imported product, and price cheaper and easy local technical service facility available, the competition will not be harsh.

FUTURE TREND

9. That the consumption of enamelled copper wire will be on the increase in Ghana is substantiated by a market study conducted by the UNIDO Project team DP/GHA/87/026. According to this study consumption of imported electrical apparatus had increased from 537.5 tons in 1984 to 1,035.9 tons in 1986 and would stabilise at this level. Nevertheless local demand is expected to expand by about 20% in the urban areas and in substantial amounts in the rural areas with the reaching of power in the villages.

EXPORT POSSIBILITIES

10. From the discussions with the traders in Ghana it is understood that there is good scope for exporting this wire to neighbouring states. This needs to be confirmed by a detailed market study. The product, will be packed in wooden cases. The packages will weigh approximately 10 to 18kgs. in single lengths.

PRICING

11. The empirical market study indicated the following ranges:

SWG (Range from to)	Rate per Kilogram in Cedis			Average
	Party A	Party B	Party C	
16 to 22	4200	3100	3200	2,800
23 to 26	5200	3700	3800	3,387
At 1:1 market mix				3,094

The above prices are net of sales tax and central excise duty. (Total 20%)

For the purpose of the study approximately 80% of this price is adopted at ¢2,520 per kg. As such the product is cheaper by 20% in the local market.

TECHNOLOGY

12. Enamelled copper wire is a specialised industry. Every manufacturer tries to keep the technical know how to himself. The wire-drawing technology has improved from slow speed machines to high speed machines, single die to multi dies, simple wire drawing to wire drawing, annealing and coiling, and enamelling in tandem. Similarly the ovens have improved from radiation heating to convection heating. With high speed machines frequent changes in gauge, will generate more scrap and frequent setting of the machine for various gauges will be difficult if not prohibitive when considered in the context of low level of basic engineering skills available in the country. It is therefore recommended that semi automatic wire drawing system be used. Since the quantity of production is only 15mts per month and the gauges covered are from 14swg. to 23swg., it is felt that a radiation type of oven is the most suitable; accordingly, this technology is recommended.

CAPACITY UTILISATION

13. With the combination suggested above full capacity utilisation can be expected from the first year of production.

PRODUCTION PROCESS

14. 8 millimeter diameter continuous cast copper rods are drawn on Rod Break Down machinery to a size of 3.64 mms. and further drawn on a multi die wire drawing machine to respective sizes. Tungsten carbide dies are used up to a size of 1.6mm diameter, subsequently diamond dies are used for drawing. The drawn wire is annealed and enamelled in an electrically heated oven. Metering of the wire enamel is done with the help of adjustable or fixed dies. The enamelled wire produced shall be inspected for mechanical, thermal, and electrical properties. The

quality is controlled stage wise by on the line inspection, and batch inspection. A detailed report on the manufacturing process, dies and tools required should be incorporated in a full feasibility study. Once the wire is tested, the same is packed on corrugated boxes and then in wooden boxes, (in case of exports) and dispatched to destination.

RAW MATERIALS

15. The main raw materials required are EC grade continuous cast copper rods of 8mm diameter. Copper rods may be imported from Zambia and enamel either from Europe or India.

EMPLOYMENT GENERATION

16. The project would employ a total strength of 30 persons.

LOCATION

17. The project can be located at Tema or Accra, as it is near to the port and capital of Ghana. This will help in the faster clearing of the import application papers, imported material etc.

LAND

18. Total land required for the Project is one acre.

BUILDING

19. Approximate floor space requirement for the unit is 700 S.M. for the works and 100 S.M. for office and stores.

PLANT, MACHINERY AND EQUIPMENT

20. Following is a summarised list of Plant and Equipment needed.

(a) Wire Drawing Bull Block Machine

(b) Wire Drawing Multi Die Machine

(c) Welding Machine

(d) Vertical Enamelling Machine

(e) Rewinding Machine

(f) Testing Machinery for all tests as per ISS 4800 Part I to Part V

(g) Tungsten carbide and Diamond Dies

(h) Steel Re.ls

(i) Tools

(j) Material handling Equipments

(k) Weighing Scales

(l) Electrical Stepdown Transformer

(m) Electrical High Tension and Low Tension Panel Board.

ORGANISATION, MANAGEMENT AND LABOUR

21. The company shall be managed by a Works Manager under the overall supervision of the Board of Directors.

The following estimates of manpower requirement is made:

	Nos.
Works Manager	1
Shift Supervisors	4
Electrician/) Mechanics) Technicians)	2
Q.C. Technicians	2
Workers	19
Office staff	3
Watchmen/Security	4

INVESTMENT INCENTIVES

22. A detailed feasibility study will give exact details of incentives available for new industries. However, it is understood that the Government of Ghana, embarked on an Economic Recovery Programme, offers good incentives for setting up of new units in the form of exemptions in customs duty in case of plant and machinery, investment allowance approximately 7½%, depreciation, or capital allowance of 40% in the year of investment etc.

INVESTMENT

23. Project Investment is estimated as under:

	(in ¢Million)
Land and Buildings	54.000
Plant & Machinery	77.280
Training and Technology	24.000
Preoperative Expenses	8.473
Interest during Construction	18.140
Working Capital	45.220
Total Investment	227.113

PROJECT FINANCING

24. The expected financing scheme would be as follows:

	(in ¢Million)		
	Local Currency	Foreign Currency	Total
Equity	62.68	-	62.68
Loans	22.69	123.60	146.29
Total	85.37	123.60	208.97

Debt Equity ratio = : 2.3:1

OPERATING RESULTS

25. The following are indicative figures regarding the operating income and expenses at 100% capacity operation:

	(In ¢Million)
Sales	453.60
Materials	194.16
Labour	7.54
Production overheads	42.28
Spares and Maintenance	20.00
Administration	4.80
Selling and Distribution	-
Total Expenses	268.78
Depreciation	19.134
Interest charges	35.573
Total Costs	323.487
Profits	130.113
Profits as a percentage of sales ...	28.684
Profits as a percentage of Investment	59.420
Profits as a percentage of equity	207.583
Breakeven Point	30.5%
Pay Back	2 years
Tentative I.R.R.	82.25%

26. The above estimates have been prepared using the UNIDO COMPUTER MODEL FOR FEASIBILITY ANALYSIS AND REPORTING (COMFAR). A set of relevant schedules produced by COMFAR is attached for detailed information.

NATIONAL BENEFITS INCLUDING FOREIGN EXCHANGE SAVINGS

27. The project is based on imported raw material, and high local value added. Hence this project shall be able to produce an import substitutive product and save valuable foreign exchange.

28. It is estimated that the unit will fetch at least about ¢100 million per month in foreign sales.

Estimated European market price based on LME rate of £1600 PMT, @ £3840 PMT works out to ¢2.236 million PMT. As against this estimated expenses in foreign exchange for raw material, ¢188.04 million per annum, and depreciation imported assets/machinery ¢8.24 million; totalling, ¢196.44 million. This leaves a Net Savings of ¢206.00 million per year. (Approximately US$0.62 million per year). A conservative estimate could be US$0.50 million per year @ 0.8 probability level.

ANNEX 1

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

PROJECT IN THE REPUBLIC OF GHANA

Feasibility Analysis Unit for Pre-investment Studies
at the National Investment Bank (NIB)

JOB DESCRIPTION

DP/GHA/87/026/11-61

Post title Industrial Engineer (Telephone cables, alauminium wires, cables, and other telephone equipment)

Duration 0.5 man-months

Date required 1 March 1990

Duty station Accra, Ghana

Purpose of project

- Enable the Government, the National Investment Bank (NIB) and other sponsors to decide on the implementation of industrial projects through the establishment of a Feasibility Analysis Unit at NIB; this unit will enable NIB and its potential clients to
  - o Identify new industrial investment projects;
  - o Assess their industrial investment potential;
  - o Prepare and evaluate techno-economic feasibility studies;
  - o Appraise the modernisation, diversification or expansion of existing industrial ventures.
- Build up an investment portfolio consisting of industrial project proposals of an innovative or pioneering nature.
- Strengthen the capacity of NIB to provide training and consulting services to improve industrial project evaluation and preparation of pre-feasibility and feasibility studies.

DUTIES

Under the supervision of the Chief Technical Adviser and in cooperation with other members of the Project team the expert shall conduct a technical study of the following Project proposals and prepare a pre-feasibility study to enable the Government of Ghana to decide on further

..../..

implementation priorities in respect of establishment of small/medium scale projects for the production of wires, cables and other accessories for the telephone industry

In particular the expert shall :

(1) Assess and advise on the suitability of the available raw & auxiliary materials, utilities, manpower and other inputs.
(5) Advise on the additional or supplementary sources for such inputs
(6) Prepare a technical report outlining
-Equipment, Physical facilities, raw materials and other inputs required, manpower needs, training, technology, environment and waste management for producing equipment and accessories relevant to the telephone industry in particular and aluminium wire making industry in general.
-An evaluation of available techonologies bringing out their merits and demerits and suggestions for adoption in Ghana
-Production/process flow highlighting bottlenecks and problem areas with indicative solutions.
-Any other information of particular importance or relevance in relation to the projects under development or the sources and quality of equipment, or other inputs or environment.
(7) Provide such other inputs to the project activities including training as may lie within the sphere of his competence.

The expert will also be expected to submit a report on the findings of his mission, suggestions and comments.

QUALIFICATIONS Must hold an advance level university degree in the appropriate area of specialisation and must possess extensive experience of relevance

LANGUAGE English

BACKGROUND INFORMATION : The Government of Ghana places special emphasis on the development of industries which have a capacity for increasing domestic resource use. Although significant progress has been made since 1984 the country remains heavily dependent on the flow of foreign capital. The reforms undertaken during the past three years should ensure that positive growth is maintained in the major economic sectors during the next two years. This growth must be accompanied by fundamental structural changes within these sectors in order to generate self-sustaining development capacity.

A key role will have to be played by the development financing institutions of Ghana, particularly by the National Investment Bank (NIB). As the foreign exchange constraints tightened, opportunities for expanding manufacturing investment were reduced. The Government has in recent years relied on foreign finance as a source of industrial investment and credit worth US$ 53.5 million has been obtained in 1986 to permit an expansion of industrial imports and to facilitate industrial sector rehabilitation.

The share of the private sector joint venture firms will have to increase in 1989/90. The Government's recent emphasis on privatisation is also likely to further increase the role of joint ventures in Ghanaian manufacturing. NIB will have to revitalise its business, which was so far confined to small scale production, and will, therefore, in the short and medium run, continue to depend on its capacity to channel domestic finance and foreign exchange allocations to well defined, profitable and bankable industrial projects. As a step towards this goal, the Feasibility Analysis Unit for pre-investment studies is assigned to the NIB.

DP/GHA/87/026
28.8.90
ENAMELLED COPPER WIRE

1 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 2.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: CEDIS million

Total initial investment during construction phase

fixed assets:	181.89	61.272 % foreign
current assets:	45.22	36.709 % foreign
total assets:	227.11	56.392 % foreign

Source of funds during construction phase

equity & grants:	62.68	0.000 % foreign
foreign loans :	123.60	
local loans :	22.69	
total funds :	208.97	59.147 % foreign

Cashflow from operations

Year:	1	2	3
operating costs:	268.78	268.78	268.78
depreciation :	19.13	19.13	19.13
interest :	35.57	31.94	28.30
production costs	323.49	319.85	316.22
thereof foreign	72.19 %	72.05 %	71.90 %
total sales :	453.60	453.60	453.60
gross income :	130.11	133.75	137.38
net income :	130.11	133.75	137.38
cash balance :	105.91	138.25	141.89
net cashflow :	156.12	184.82	184.82

Net Present Value at: 20.00 % = 636.65
Internal Rate of Return: 82.25 %
Return on equity1: 210.39 %
Return on equity2: 187.97 %

Index of Schedules produced by COMFAR

Total initial investment
Total investment during production
Total production costs
Capital requirements
Cashflow Tables
Projected Balance
Net income statement
Source of finance

Total Initial Investment in CEDIS million

Year	1990
Fixed investment costs	
Land, site preparation, development	6.000
Buildings and civil works	48.000
Auxiliary and service facilities	0.000
Incorporated fixed assets	29.720
Plant machinery and equipment	77.280
Total fixed investment costs	161.000
Pre-production capital expenditures	20.893
Net working capital	45.220
Total initial investment costs	227.113
Of it foreign, in %	56.382

Total Current Investment in CEDIS million

Year	1991
Fixed investment costs	
Land, site preparation, development	0.000
Buildings and civil works	0.000
Auxiliary and service facilities	0.000
Incorporated fixed assets	0.000
Plant, machinery and equipment	0.000
Total fixed investment costs	0.000
Preproduction capitals expenditures	0.000
Working capital	28.704
Total current investment costs	28.704
Of it foreign, %	76.429

Source of Finance, construction in CEDIS million

9,E 4

Year	1990
Equity, ordinary ..	62.680
Equity, preference.	0.000
Subsidies, grants .	0.000
Loan A, foreign .	123.600
Loan B, foreign..	0.000
Loan C, foreign .	0.000
Loan A, local....	22.690
Loan B, local....	0.000
Loan C, local....	0.000
Total loan	146.290
Current liabilities	0.000
Bank overdraft	18.143
Total funds	227.113

Source of Finance, production in CEDIS million

Year	1991	1992-2000
Equity, ordinary ..	0.000	0.000
Equity, preference.	0.000	0.000
Subsidies, grants .	0.000	0.000
Loan A, foreign .	-12.360	-12.360
Loan B, foreign..	0.000	0.000
Loan C, foreign .	0.000	0.000
Loan A, local....	-2.269	-2.269
Loan B, local....	0.000	0.000
Loan C, local....	0.000	0.000
Total loan	-14.629	-14.629
Current liabilities	0.733	0.000
Bank overdraft	-18.143	0.000
Total funds	-32.039	-14.629

Total Production Costs in CEDIS million

ACP 6.

Year	1991	1992	1993	1994	1995	1996	1997	1998		2000
% of nom. capacity (single product).	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000		100.000
Raw material 1	188.040	188.040	188.040	188.040	188.040	188.040	188.040	188.040		188.040
Other raw materials	6.120	6.120	6.120	6.120	6.120	6.120	6.120	6.120		6.120
Utilities	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
Energy	2.280	2.280	2.280	2.280	2.280	2.280	2.280	2.280		2.280
Labour, direct	7.540	7.540	7.540	7.540	7.540	7.540	7.540	7.540		7.540
Repair, maintenance	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000		20.000
Spares	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
Factory overheads	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000		40.000
Factory costs	263.980	263.980	263.980	263.980	263.980	263.980	263.980	263.980		263.980
Administrative overheads	4.800	4.800	4.800	4.800	4.800	4.800	4.800	4.800		4.800
Indir. costs, sales and distribution	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
Direct costs, sales and distribution	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
Depreciation	19.134	19.134	19.134	19.134	19.134	10.700	10.700	10.700		2.972
Financial costs	35.573	31.939	28.304	24.669	21.035	17.400	13.766	10.131		2.317
Total production costs	323.487	319.853	316.218	312.583	308.949	296.880	293.246	289.611		274.069
Costs per unit (single product)	1.797	1.777	1.757	1.737	1.716	1.649	1.629	1.609		1.523
Of it foreign, %	72.191	72.046	71.896	71.744	71.588	70.616	70.438	70.255		69.456
Of it variable,%	66.467	67.222	67.995	68.785	69.594	72.423	73.321	74.241		78.451
Total labour	7.540	7.540	7.540	7.540	7.540	7.540	7.540	7.540		7.540

PAGE. F.

Total Production Costs in CEDIS million

Year	2001- 5
% of nom. capacity (single product).	100.000
Raw material 1	188.040
Other raw materials	6.120
Utilities	0.000
Energy	2.280
Labour, direct	7.540
Repair, maintenance	20.000
Spares	0.000
Factory overheads	40.000
Factory costs	263.980
Administrative overheads	4.800
Indir. costs, sales and distribution	0.000
Direct costs, sales and distribution	0.000
Depreciation	2.400
Financial costs	-0.000
Total production costs	271.180
Costs per unit (single product)	1.507
Of it foreign, %	69.341
Of it variable,%	79.297
Total labour	7.540

PAGE 8

Net Working Capital in CEDIS million

Year			1991	1992-2005
Coverage	adc	coto		
Current assets &				
Accounts receivable	1	360.0	0.747	0.747
Inventory and materials	39	9.3	66.130	66.130
Energy	1	360.0	0.006	0.006
Spares	0	---	0.000	0.000
Work in progress	5	71.6	3.687	3.687
Finished products	5	69.2	3.887	3.887
Cash in hand	1	360.0	0.201	0.201
Total current assets			74.657	74.657
Current liabilities and				
Accounts payable	1	360.0	0.733	0.733
Net working capital			73.924	73.924
Increase in working capital			28.704	0.000
Net working capital, local			35.386	35.386
Net working capital, foreign			38.538	38.538

Note: adc = minimum days of coverage ; coto = coefficient of turnover .

Cashflow Tables, construction in CEDIS million

PAGE. 9.

Year	1990
Total cash inflow . .	208.970
Financial resources .	208.970
Sales, net of tax . .	0.000
Total cash outflow . .	227.113
Total assets	209.940
Operating costs . . .	0.000
Cost of finance . . .	18.173
Repayment	0.000
Corporate tax . . .	0.000
Dividends paid . . .	0.000
Surplus (deficit) .	-18.143
Cumulated cash balance	-18.143
Inflow, local	85.370
Outflow, local	99.063
Surplus (deficit) .	-13.693
Inflow, foreign . . .	123.600
Outflow, foreign . . .	128.050
Surplus (deficit) .	-4.450
Net cashflow	-208.940
Cumulated net cashflow	-208.940

PAGE. 10.

Cashflow tables, production in CEDIS million

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total cash inflow	454.333	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600
Financial resources	0.733	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sales, net of tax	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600
Total cash outflow	348.419	315.348	311.715	308.076	304.444	300.809	297.175	293.540	289.906	285.747	268.780
Total assets	29.437	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Operating costs	268.780	268.780	268.780	268.780	268.780	268.780	268.780	268.780	268.780	268.780	268.780
Cost of finance	35.573	31.939	28.304	24.669	21.035	17.400	13.766	10.131	6.497	2.317	-0.000
Repayment	14.629	14.629	14.629	14.629	14.629	14.629	14.629	14.629	14.629	14.629	0.000
Corporate tax	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dividends paid	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Surplus (deficit)	105.914	138.252	141.887	145.522	149.156	152.791	156.425	160.060	163.694	167.874	184.820
Cumulated cash balance	87.771	226.024	367.911	513.432	662.588	815.379	971.804	1131.864	1295.559	1463.432	1648.252
Inflow, local	340.411	340.200	340.200	340.200	340.200	340.200	340.200	340.200	340.200	340.200	340.200
Outflow, local	95.431	87.910	87.365	86.821	86.276	85.732	85.187	84.643	84.098	83.009	80.740
Surplus (deficit)	244.979	252.290	252.835	253.379	253.924	254.468	255.013	255.557	256.102	257.191	259.460
Inflow, foreign	113.922	113.400	113.400	113.400	113.400	113.400	113.400	113.400	113.400	113.400	113.400
Outflow, foreign	252.988	227.438	224.349	221.258	218.168	215.078	211.988	208.898	205.808	202.718	188.040
Surplus (deficit)	-139.066	-114.037	-110.948	-107.858	-104.768	-101.678	-98.588	-95.498	-92.408	-89.318	-74.640
Net cashflow	156.116	184.820	184.820	184.820	164.820	184.820	184.820	184.820	184.820	184.820	184.820
Cumulated net cashflow	-52.824	131.996	316.816	501.636	686.456	871.276	1056.096	1240.916	1425.736	1610.556	1795.376

PAGE. 11.

Cashflow tables, production in CEDIS million

Year	2003	2003	2004	2005
Total cash inflow	453.600	453.600	453.600	453.600
Financial resources	0.000	0.000	0.000	0.000
Sales revenues	453.600	453.600	453.600	453.600
Total cash outflow	268.780	268.780	268.780	268.780
Total assets	0.000	0.000	0.000	0.000
Operating costs	268.780	268.780	268.780	268.780
Cost of finance	-0.000	-0.000	-0.000	-0.000
Repayment	0.000	0.000	0.000	0.000
Corporate tax	0.000	0.000	0.000	0.000
Dividends paid	0.000	0.000	0.000	0.000
Surplus (deficit)	184.820	184.820	184.820	184.820
Cumulated cash balance	1833.072	2017.892	2202.712	2387.532
Inflow, local	340.200	340.200	340.200	340.200
Outflow, local	80.740	80.740	80.740	80.740
Surplus (deficit)	259.460	259.460	259.460	259.460
Inflow, foreign	113.400	113.400	113.400	113.400
Outflow, foreign	188.040	188.040	188.040	188.040
Surplus (deficit)	-74.640	-74.640	-74.640	-74.640
Net cashflow	184.820	184.820	184.820	184.820
Cumulated net cashflow	1920.176	2105.016	2289.836	2534.656

PAGE 12.

Cashflow Discounting:

a) Equity paid versus Net income flow:

Net present value	[illegible] at	20.00 %
Internal Rate of Return (IRRE!) ..	210.39 %	

b) Net Worth versus Net cash return:

Net present value	619.57 at	20.00 %
Internal Rate of Return (IRRE!) ..	[illegible] %	

c) Internal Rate of Return on total investment:

Net present value	[illegible] at	20.00 %
Internal Rate of Return (IRR) ..	[illegible] %	

Net Worth = Equity, paid plus reserves

COMFAR 2.1 -NATIONAL INVESTMENT BANK, ACCRA, GHANA-----

PAGE. 13.

Net Income Statement in CEDIS million

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total sales, incl. sales tax	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600	453.600
Less: variable costs, incl. sales tax	215.011	215.011	215.011	215.011	215.011	215.011	215.011	215.011	215.011	215.011
Variable margin	238.589	238.589	238.589	238.589	238.589	238.589	238.589	238.589	238.589	238.589
As % of total sales	52.599	52.599	52.599	52.599	52.599	52.599	52.599	52.599	52.599	52.599
Non-variable costs, incl. depreciation	72.903	72.903	72.903	72.903	72.903	64.469	64.469	64.469	64.469	56.741
Operational margin	165.686	165.686	165.686	165.686	165.686	174.120	174.120	174.120	174.120	181.848
As % of total sales	36.527	36.527	36.527	36.527	36.527	38.398	38.398	38.398	38.398	40.090
Cost of finance	35.573	31.939	28.304	24.669	21.035	17.400	13.766	10.131	6.497	2.317
Gross profit	130.113	133.747	137.382	141.017	144.651	156.720	160.354	163.989	167.623	179.530
Allowances	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Taxable profit	130.113	133.747	137.382	141.017	144.651	156.720	160.354	163.989	167.623	179.530
Tax	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Net profit	130.113	133.747	137.382	141.017	144.651	156.720	160.354	163.989	167.623	179.530
Dividends paid	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Undistributed profit	130.113	133.747	137.382	141.017	144.651	156.720	160.354	163.989	167.623	179.530
Accumulated undistributed profit	130.113	263.860	401.242	542.259	686.910	843.630	1003.984	1167.973	1335.596	1515.127
Gross profit, % of total sales	28.684	29.486	30.287	31.088	31.890	34.550	35.351	36.153	36.954	39.579
Net profit, % of total sales	28.684	29.486	30.287	31.088	31.890	34.550	35.351	36.153	36.954	39.579
ROE, Net profit, % of equity	207.583	213.381	219.180	224.979	230.777	250.031	255.830	261.629	267.427	286.424
ROI, Net profit+interest, % of invest.	69.720	69.720	69.720	69.720	69.720	73.269	73.269	73.269	73.269	76.521

PAGE 14.

Net Income Statement in CEDIS million

Year	2001	2002	2003	2004	2005
Total sales, incl. sales tax	453.600	453.600	453.600	453.600	453.600
Less: variable costs, incl. sales tax	215.011	215.011	215.011	215.011	215.011
Variable margin	238.589	238.589	238.589	238.589	238.589
As % of total sales	52.599	52.599	52.599	52.599	52.599
Non-variable costs, incl. depreciation	56.169	56.169	56.169	56.169	56.169
Operational margin	182.420	182.420	182.420	182.420	182.420
As % of total sales	40.216	40.216	40.216	40.216	40.216
Cost of finance	-0.000	-0.000	-0.000	-0.000	-0.000
Gross profit	182.420	182.420	182.420	182.420	182.420
Allowances	0.000	0.000	0.000	0.000	0.000
Taxable profit	182.420	182.420	182.420	182.420	182.420
Tax	0.000	0.000	0.000	0.000	0.000
Net profit	182.420	182.420	182.420	182.420	182.420
Dividends paid	0.000	0.000	0.000	0.000	0.000
Undistributed profit	182.420	182.420	182.420	182.420	182.420
Accumulated undistributed profit	1697.547	1879.967	2062.387	2244.807	2427.227
Gross profit, % of total sales	40.216	40.216	40.216	40.216	40.216
Net profit, % of total sales	40.216	40.216	40.216	40.216	40.216
ROE, Net profit, % of equity	291.034	291.034	291.034	291.034	291.034
ROI, Net profit+interest, % of invest.	76.762	76.762	76.762	76.762	76.762

Projected Balance Sheets, construction in CEDIS million

PAGE.15

Year	1990
Total assets	227.113
Fixed assets, net of depreciation	0.000
Construction in progress	181.693
Current assets	45.420
Cash, bank	0.000
Cash surplus, finance available	0.000
Loss carried forward	0.000
Loss	0.000
Total liabilities	227.113
Equity capital	62.680
Reserves, retained profit	0.000
Profit	0.000
Long and medium term debt	146.290
Current liabilities	0.020
Bank overdraft, finance required	18.143
Total debt	164.433
Equity, % of liabilities	27.599

Projected Balance Sheets, Production in CEDIS million

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total assets	325.187	444.306	567.059	693.446	823.468	965.559	1111.284	1260.644	1413.639	1576.540	1760.960
Fixed assets, net of depreciation	162.759	143.625	124.491	105.357	86.223	75.523	64.823	54.123	43.423	40.451	30.851
Construction in progress	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Current assets	74.456	74.456	74.456	74.456	74.456	74.456	74.456	74.456	74.456	74.456	74.456
Cash, bank	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201
Cash surplus, finance available	87.771	226.024	367.911	513.432	662.588	815.379	971.804	1131.864	1295.559	1465.432	1648.252
Loss carried forward	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Loss	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total liabilities	325.187	444.306	567.059	693.446	823.468	965.559	1111.284	1260.644	1413.639	1576.540	1760.960
Equity capital	62.680	62.680	62.680	62.680	62.680	62.680	62.680	62.680	62.680	62.680	62.680
Reserves, retained profit	0.000	130.113	263.860	401.242	542.259	696.910	845.630	1003.934	1167.973	1332.592	1515.127
Profit	130.113	133.747	137.382	141.017	144.651	150.720	160.304	160.989	167.623	179.530	182.426
Long and medium term debt	131.661	117.032	102.403	87.774	73.145	58.516	43.887	29.258	14.629	-0.000	-0.044
Current liabilities	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733
Bank overdraft, finance required	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.044
Total debt	132.394	117.765	103.136	88.507	73.878	59.249	44.620	29.991	15.362	0.733	0.733
Equity, % of liabilities	19.275	14.107	11.054	9.039	7.612	6.492	5.640	4.972	4.434	3.971	3.559

Projected Balance Sheets, Production in CEDIS million

Year	2002	2003	2004	2005
Total assets	1943.380	2125.800	2308.220	2490.640
Fixed assets, net of depreciation	35.651	33.251	30.851	28.451
Construction in progress	0.000	0.000	0.000	0.000
Current assets	74.456	74.456	74.456	74.456
Cash, bank	0.201	0.201	0.201	0.201
Cash surplus, finance available	1833.072	2017.892	2202.712	2387.532
Loss carried forward	0.000	0.000	0.000	0.000
Loss	0.000	0.000	0.000	0.000
Total liabilities	1943.380	2125.800	2308.220	2490.640
Equity capital	62.680	62.680	62.680	62.680
Reserves, retained profit	1697.547	1879.967	2062.387	2244.807
Profit	182.426	182.426	182.426	182.426
Long and medium term debt	-0.000	-0.000	-0.000	-0.000
Current liabilities	0.733	0.733	0.733	0.733
Bank overdraft, finance required	0.000	0.000	0.000	0.000
Total debt	0.733	0.733	0.733	0.733
Equity, % of liabilities	3.225	2.949	2.716	2.517

Table : A

DIAMETERS - TOLERANCES - AREA - WEIGHT & RESISTANCE OF COPPER CONDUCTORS OF ENAMELLED ROUND WINDING WIRES (SWG SIZES)

(BASIS IS 4800 : PART I & II)

SWG	mm	Conductor tolerance	Conductor Diameter		Nominal Conductor area	Conductor Weight for 1000m length	Conductor Resistance at 20°C for 1 metre in ohms		
			min	max					
		mm	mm	mm	mm^2	kg	nominal	maximum	minimum
11	2.946	±0.029	2.917	2.975	6.81640	60.598	0.002529		
12	2.642	±0.026	2.616	2.668	5.48221	48.737	0.003145		
13	2.337	±0.023	2.314	2.360	4.28951	38.134	0.004019		
14	2.032	±0.020	2.012	2.052	3.24293	28.830	0.005317		
15	1.829	±0.018	1.811	1.847	2.62735	23.357	0.006562		
16	1.626	±0.016	1.610	1.642	2.07650	18.460	0.008303		
17	1.422	±0.014	1.408	1.436	1.58814	14.119	0.01086		
18	1.219	±0.012	1.207	1.231	1.16707	10.375	0.01478		
19	1.016	±0.010	1.006	1.026	0.81073	7.207	0.02127		
20	0.914	±0.009	0.905	0.923	0.65612	5.833	0.0263	0.0270	0.0255
21	0.813	±0.008	0.805	0.821	0.51912	4.615	0.0332	0.0342	0.0323
22	0.711	±0.007	0.704	0.718	0.39704	3.530	0.0434	0.0447	0.0422
23	0.610	±0.006	0.604	0.616	0.29225	2.598	0.0590	0.0607	0.0574
24	0.559	±0.006	0.553	0.565	0.24542	2.182	0.0703	0.0724	0.0682
25	0.508	±0.005	0.503	0.513	0.20268	1.802	0.0851	0.0875	0.0827
26	0.457	±0.005	0.452	0.462	0.16403	1.458	0.1051	0.1084	0.1020
27	0.417	±0.005	0.412	0.422	0.13657	1.214	0.1262	0.1305	0.1222
28	0.376	±0.005	0.371	0.381	0.11104	0.987	0.1553	0.1609	0.1499
29	0.345	±0.004	0.341	0.349	0.09348	0.831	0.1844	0.1904	0.1787
30	0.315	±0.004	0.311	0.319	0.07793	0.693	0.2212	0.2289	0.2139
31	0.295	±0.004	0.291	0.299	0.06835	0.608	0.2523	0.2615	0.2435
32	0.274	±0.004	0.270	0.278	0.05896	0.524	0.2924	0.3037	0.2816
33	0.254	±0.004	0.250	0.258	0.05067	0.450	0.3403	0.3543	0.3270
34	0.234	±0.003	0.231	0.237	0.04301	0.382	0.4009	0.4150	0.3875
35	0.213	±0.003	0.210	0.216	0.03563	0.317	0.4839	0.5022	0.4665
36	0.193	±0.003	0.190	0.196	0.02926	0.260	0.5893	0.6134	0.5666
37	0.173	±0.003	0.170	0.176	0.02351	0.209	0.7335	0.7662	0.7026
38	0.152	±0.003	0.149	0.155	0.01815	0.161	0.950	0.9974	0.9059
39	0.132	±0.003	0.129	0.135	0.01368	0.122	1.260	1.331	1.194
40	0.122	±0.003	0.119	0.125	0.01169	0.104	1.475	1.564	1.393
41	0.112	±0.003	0.109	0.115	0.00985	0.088	1.750	1.864	1.646
42	0.102	±0.003	0.099	0.105	0.00817	0.073	2.110	2.259	1.974
43	0.091	±0.003	0.088	0.094	0.00650	0.058	2.651	2.850	2.452
44	0.081	±0.003	0.078	0.084	0.00515	0.046	3.346	3.614	3.078
45	0.071	±0.003	0.068	0.074	0.00396	0.035	4.355	4.725	3.985
46	0.061				0.00292	0.026	5.900	6.431	5.369
47	0.051				0.00204	0.018	8.440	9.284	7.596
48	0.041				0.00132	0.012	13.06	14.63	11.62

Table : A1

DIAMETERS-TOLERANCES-AREA-WEIGHT & RESISTANCE OF COPPER CONDUCTORS OF ENAMELLED ROUND WINDING WIRES (METRIC SIZES)
(BASIS IS 4800 : PART I & II)

Conductor diameter	Conductor tolerance	Conductor Diameter		Nominal Conductor area	Conductor Weight for 1000m	Conductor Resistance at 20°C for 1 metre in ohms		
		min	max					
mm	mm	mm	mm	mm^2	kg	nominal	maximum	minimum
0.040	0.003	0.037	0.043	0.00126	0.011	13.72	15.37	12.21
0.050	0.003	0.047	0.053	0.00196	0.019	8.781	9.559	7.903
0.060	0.003	0.057	0.063	0.00283	0.025	6.098	6.647	5.549
0.063	0.003	0.060	0.066	0.00312	0.028	5.531	6.029	5.033
0.071	0.003	0.068	0.074	0.00396	0.035	4.355	4.725	3.985
0.080	0.003	0.077	0.083	0.00503	0.044	3.430	3.704	3.156
0.090	0.003	0.087	0.093	0.00636	0.057	2.710	2.913	2.507
0.100	0.003	0.097	0.103	0.00785	0.070	2.195	2.349	2.041
0.112	0.003	0.109	0.115	0.00985	0.088	1.750	1.864	1.646
0.118	0.003	0.115	0.121	0.01093	0.097	1.577	1.674	1.487
0.125	0.003	0.122	0.128	0.01227	0.109	1.405	1.488	1.328
0.132	0.003	0.129	0.135	0.01368	0.121	1.260	1.331	1.194
0.140	0.003	0.137	0.143	0.01539	0.136	1.120	1.180	1.064
0.160	0.003	0.157	0.163	0.02011	0.179	0.8575	0.8983	0.8192
0.170	0.003	0.167	0.173	0.02270	0.202	0.7596	0.7940	0.7272
0.180	0.003	0.177	0.183	0.02545	0.226	0.6775	0.7068	0.6499
0.190	0.003	0.187	0.193	0.02835	0.252	0.6081	0.6332	0.5843
0.195	0.003	0.192	0.198	0.02986	0.265	0.5773	0.6007	0.5552
0.200	0.003	0.197	0.203	0.03142	0.279	0.5488	0.5706	0.5282
0.212	0.003	0.209	0.215	0.03530	0.314	0.4884	0.5069	0.4708
0.224	0.003	0.221	0.227	0.03941	0.350	0.4375	0.4534	0.4224
0.236	0.003	0.233	0.239	0.04374	0.388	0.3941	0.4079	0.3810
0.243	0.004	0.239	0.247	0.04638	0.412	0.3718	0.3877	0.3567
0.250	0.004	0.246	0.254	0.04909	0.436	0.3512	0.3659	0.3374
0.265	0.004	0.261	0.269	0.05515	0.490	0.3126	0.3251	0.3008
0.273	0.004	0.269	0.277	0.05853	0.520	0.2945	0.3060	0.2837
0.280	0.004	0.276	0.284	0.06157	0.547	0.2800	0.2907	0.2698
0.300	0.004	0.296	0.304	0.07069	0.628	0.2439	0.2527	0.2355
0.315	0.004	0.311	0.319	0.07793	0.693	0.2212	0.2289	0.2139
0.345	0.004	0.349	0.349	0.09348	0.831	0.1844	0.1904	0.1787
0.355	0.004	0.351	0.359	0.09898	0.880	0.1742	0.1797	0.1689
0.375	0.004	0.371	0.379	0.11045	0.982	0.1561	0.1609	0.1515
0.400	0.005	0.395	0.405	0.12566	1.117	0.1372	0.1419	0.1327
0.412	0.005	0.407	0.417	0.13332	1.185	0.1293	0.1337	0.1252
0.450	0.005	0.445	0.455	0.15904	1.414	0.1084	0.1118	0.1051
0.500	0.005	0.495	0.505	0.19635	1.746	0.08781	0.09037	0.08534
0.560	0.006	0.554	0.566	0.24630	2.190	0.07000	0.07215	0.06794
0.600	0.006	0.594	0.606	0.28274	2.514	0.06098	0.06276	0.05927

Table : A2

DIAMETERS-TOLERANCES-AREA-WEIGHT & RESISTANCE OF COPPER CONDUCTORS OF ENAMELLED ROUND WINDING WIRES (METRIC SIZES) (BASIS IS 4800 : PART I & II)

Conductor diameter	Conductor tolerance	Conductor Diameter		Nominal Conductor area	Conductor Weight for 1000m	Conductor Resistance at 20°C for 1 metre in ohms		
		min	max					
mm	mm	mm	mm	mm^2	kg	nominal	maximum	minimum
0.630	0.006	0.624	0.636	0.31172	2.771	0.05531	0.05687	0.05381
0.710	0.007	0.703	0.717	0.39592	3.520	0.04355	0.04481	0.04234
0.750	0.008	0.742	0.758	0.44179	3.928	0.03903	0.04022	0.03788
0.800	0.008	0.792	0.808	0.50265	4.469	0.03430	0.03530	0.03334
0.813	0.008	0.805	0.821	0.51912	4.615	0.03321	0.03417	0.03229
0.850	0.009	0.841	0.859	0.56745	5.045	0.03038	0.03131	0.02950
0.900	0.009	0.891	0.909	0.63617	5.656	0.02710	0.02789	0.02634
0.914	0.009	0.905	0.923	0.65612	5.833	0.02628	0.02704	0.02555
0.950	0.010	0.940	0.960	0.70882	6.301	0.02432	0.02506	0.02362
0.965	0.010	0.955	0.975	0.7318	6.502	0.02357	0.02428	0.02290
1.000	0.010	0.990	1.010	0.78540	6.982	0.02195	0.02259	0.02134
1.030	0.010	1.020	1.040	0.83323	7.407	0.02069		
1.060	0.011	1.049	1.071	0.88247	7.845	0.01954		
1.120	0.011	1.109	1.131	0.98520	8.759	0.01750		
1.180	0.012	1.168	1.192	1.09359	9.722	0.01577		
1.219	0.012	1.207	1.231	1.16707	10.375	0.01477		
1.250	0.013	1.237	1.263	1.22718	10.910	0.01405		
1.320	0.013	1.307	1.333	1.36848	12.166	0.01260		
1.400	0.014	1.386	1.414	1.53938	13.685	0.01120		
1.500	0.015	1.485	1.515	1.76715	15.710	0.009757		
1.600	0.016	1.584	1.616	2.01062	17.874	0.008575		
1.626	0.016	1.610	1.642	2.07650	18.460	0.008303		
1.700	0.017	1.683	1.717	2.26980	20.179	0.007596		
1.800	0.018	1.782	1.818	2.54469	22.622	0.006775		
1.900	0.019	1.881	1.919	2.83529	25.206	0.006081		
2.000	0.020	1.980	2.020	3.14159	27.929	0.005488		
2.120	0.021	2.099	2.141	3.52990	31.381	0.004884		
2.240	0.022	2.218	2.262	3.94081	35.034	0.004375		
2.360	0.024	2.336	2.384	4.37435	38.888	0.003941		
2.500	0.025	2.475	2.525	4.90873	43.639	0.003512		
2.650	0.027	2.623	2.677	5.51546	49.032	0.003126		
2.800	0.028	2.772	2.828	6.15752	54.740	0.002800		
3.000	0.030	2.970	3.030	7.06858	62.840	0.002439		
3.150	0.032	3.118	3.182	7.79311	69.281	0.002212		
3.245	0.034	3.211	3.279	8.27026	73.523	0.002085		
3.350	0.034	3.316	3.384	8.81413	78.358	0.001956		
3.550	0.036	3.514	3.586	9.89798	87.993	0.001742		
3.660	0.038	3.522	3.698	10.52088	93.531	0.001639		

Table B

DIAMETERS AND INCREASE IN DIAMETERS OF ENAMELLED ROUND WINDING WIRES SWG SIZES (BASIS IS 4800 : PART I & II)

SWG	mm	Conductor tolerance mm	Fine Covering		Medium Covering		Thick Covering	
			minimum increase mm	maximum overall dia mm	minimum increase mm	maximum overall dia mm	minimum increase mm	maximum overall dia mm
11	2.946	2.917–2.975	0.055	3.055	0.081	3.087	0.112	3.121
12	2.642	2.616–2.668	0.053	2.746	0.078	2.776	0.108	2.811
13	2.337	2.314–2.360	0.051	2.436	0.076	2.465	0.105	2.499
14	2.032	2.012–2.052	0.049	2.124	0.073	2.152	0.101	2.184
15	1.829	1.811–1.847	0.048	1.917	0.071	1.945	0.099	1.976
16	1.626	1.610–1.642	0.046	1.709	0.068	1.737	0.096	1.767
17	1.422	1.408–1.436	0.044	1.501	0.066	1.528	0.093	1.557
18	1.219	1.207–1.231	0.042	1.294	0.063	1.320	0.089	1.350
19	1.016	1.006–1.026	0.039	1.084	0.059	1.109	0.084	1.139
20	0.914	0.905–0.923	0.038	0.979	0.057	1.009	0.081	1.031
21	0.813	0.805–0.821	0.036	0.874	0.054	0.898	0.078	0.924
22	0.711	0.704–0.718	0.034	0.768	0.051	0.791	0.074	0.816
23	0.610	0.604–0.616	0.032	0.664	0.049	0.686	0.071	0.710
24	0.559	0.553–0.565	0.030	0.610	0.046	0.631	0.071	0.655
25	0.508	0.503–0.513	0.029	0.556	0.044	0.577	0.065	0.599
26	0.457	0.452–0.462	0.027	0.502	0.041	0.523	0.062	0.545
27	0.417	0.412–0.422	0.025	0.459	0.038	0.479	0.058	0.500
28	0.376	0.371–0.381	0.024	0.417	0.037	0.437	0.057	0.458
29	0.345	0.341–0.349	0.024	0.385	0.036	0.404	0.056	0.425
30	0.315	0.311–0.319	0.022	0.352	0.034	0.371	0.053	0.391
31	0.295	0.291–0.299	0.021	0.331	0.033	0.350	0.052	0.369
32	0.274	0.270–0.278	0.021	0.309	0.032	0.328	0.051	0.347
33	0.254	0.250–0.258	0.020	0.288	0.031	0.305	0.048	0.324
34	0.234	0.231–0.237	0.019	0.266	0.030	0.282	0.046	0.300
35	0.213	0.210–0.216	0.018	0.244	0.028	0.260	0.043	0.277
36	0.193	0.190–0.196	0.017	0.223	0.027	0.237	0.040	0.253
37	0.173	0.170–0.176	0.017	0.201	0.026	0.214	0.039	0.229
38	0.152	0.149–0.155	0.016	0.179	0.025	0.190	0.036	0.203
39	0.132	0.129–0.135	0.014	0.155	0.023	0.167	0.033	0.180
40	0.122	0.119–0.125	0.013	0.146	0.022	0.156	0.032	0.168
41	0.112	0.109–0.115	0.012	0.134	0.020	0.143	0.029	0.155
42	0.102	0.099–0.105	0.011	0.123	0.019	0.131	0.028	0.143
43	0.091	0.088–0.094	0.010	0.111	0.017	0.118	0.026	0.129
44	0.081	0.078–0.084	0.009	0.099	0.016	0.106	0.024	0.117
45	0.071	0.068–0.074	0.008	0.088	0.015	0.095		
46	0.061		0.007	0.076	0.013	0.083		
47	0.051		0.005	0.063	0.010	0.069		
48	0.041		0.004	0.051	0.008	0.055		

Table : B1

DIAMETERS AND INCREASE IN DIAMETERS OF ENAMELLED ROUND WINDING WIRES (METRIC SIZES) (BASIS IS 4800 : PART I & II)

Conductor diameter mm	Conductor tolerance mm	Fine Covering		Medium Covering		Thick Covering	
		minimum increase mm	maximum overall dia mm	minimum increase mm	maximum overall dia mm	minimum increase mm	maximum overall dia mm
0.040	0.037 – 0.043	0.004	0.050	0.008	0.054		
0.050	0.047 – 0.053	0.005	0.062	0.010	0.068		
0.060	0.057 – 0.063	0.007	0.076	0.013	0.083		
0.063	0.060 – 0.066	0.007	0.078	0.013	0.085		
0.071	0.068 – 0.074	0.008	0.088	0.015	0.095		
0.080	0.077 – 0.083	0.009	0.096	0.016	0.105	0.024	0.116
0.090	0.087 – 0.093	0.010	0.110	0.017	0.117	0.026	0.128
0.100	0.097 – 0.103	0.011	0.121	0.019	0.129	0.028	0.141
0.112	0.109 – 0.115	0.012	0.134	0.020	0.143	0.029	0.155
0.118	0.115 – 0.121	0.013	0.141	0.021	0.151	0.031	0.163
0.125	0.122 – 0.128	0.013	0.149	0.022	0.159	0.032	0.171
0.132	0.129 – 0.135	0.015	0.157	0.024	0.168	0.034	0.180
0.140	0.137 – 0.143	0.015	0.166	0.024	0.176	0.034	0.189
0.160	0.157 – 0.163	0.016	0.187	0.025	0.199	0.037	0.213
0.170	0.167 – 0.173	0.017	0.198	0.027	0.211	0.040	0.226
0.180	0.177 – 0.183	0.017	0.209	0.027	0.222	0.040	0.237
0.190	0.187 – 0.193	0.018	0.220	0.028	0.234	0.043	0.248
0.195	0.192 – 0.198	0.018	0.225	0.028	0.239	0.043	0.255
0.200	0.197 – 0.203	0.018	0.230	0.028	0.245	0.043	0.261
0.212	0.209 – 0.215	0.019	0.244	0.030	0.258	0.046	0.275
0.224	0.221 – 0.227	0.019	0.256	0.030	0.272	0.046	0.290
0.236	0.233 – 0.239	0.020	0.269	0.031	0.283	0.048	0.302
0.243	0.239 – 0.247	0.020	0.276	0.031	0.293	0.048	0.310
0.250	0.246 – 0.254	0.020	0.284	0.031	0.301	0.048	0.320
0.265	0.261 – 0.269	0.021	0.300	0.032	0.317	0.051	0.335
0.273	0.269 – 0.277	0.021	0.309	0.032	0.326	0.051	0.344
0.280	0.276 – 0.284	0.021	0.315	0.032	0.334	0.051	0.353
0.300	0.296 – 0.304	0.022	0.337	0.034	0.355	0.053	0.374
0.315	0.311 – 0.319	0.022	0.352	0.034	0.371	0.053	0.391
0.345	0.341 – 0.349	0.024	0.385	0.036	0.404	0.056	0.424
0.355	0.351 – 0.359	0.024	0.395	0.036	0.414	0.056	0.435
0.375	0.371 – 0.379	0.025	0.416	0.038	0.436	0.058	0.459
0.400	0.395 – 0.405	0.025	0.442	0.038	0.462	0.058	0.483
0.412	0.407 – 0.417	0.026	0.455	0.040	0.476	0.060	0.497
0.450	0.445 – 0.455	0.027	0.495	0.041	0.516	0.062	0.538
0.500	0.495 – 0.505	0.029	0.548	0.044	0.569	0.065	0.591
0.560	0.554 – 0.566	0.030	0.611	0.046	0.632	0.067	0.656
0.600	0.594 – 0.606	0.032	0.653	0.049	0.676	0.071	0.699

Table : B2

DIAMETERS AND INCREASE IN DIAMETERS OF ENAMELLED ROUND WINDING WIRES (METRIC SIZES) (BASIS IS 4800 : PART I & II)

Conductor diameter mm	Conductor tolerance mm	Fine Covering		Medium Covering		Thick Covering	
		minimum increase mm	maximum overall dia mm	minimum increase mm	maximum overall dia mm	minimum increase mm	maximum overall dia mm
0.630	0.624 – 0.636	0.032	0.684	0.049	0.706	0.071	0.730
0.710	0.703 – 0.717	0.034	0.767	0.051	0.790	0.074	0.815
0.750	0.742 – 0.758	0.035	0.809	0.052	0.832	0.075	0.858
0.800	0.792 – 0.808	0.036	0.861	0.054	0.885	0.078	0.911
0.813	0.805 – 0.821	0.037	0.874	0.055	0.899	0.079	0.924
0.850	0.841 – 0.859	0.037	0.913	0.055	0.937	0.079	0.964
0.900	0.891 – 0.909	0.038	0.965	0.057	0.990	0.081	1.017
0.914	0.905 – 0.923	0.039	0.979	0.058	1.003	0.082	1.030
0.950	0.940 – 0.960	0.039	1.017	0.058	1.041	0.082	1.070
0.965	0.955 – 0.975	0.039	1.032	0.059	1.057	0.084	1.084
1.000	0.990 – 1.010	0.039	1.068	0.059	1.093	0.084	1.123
1.030	1.020 – 1.040	0.040	1.099	0.060	1.124	0.085	1.151
1.060	1.049 – 1.071	0.040	1.130	0.060	1.155	0.085	1.184
1.120	1.109 – 1.131	0.041	1.192	0.061	1.217	0.087	1.246
1.180	1.168 – 1.192	0.042	1.254	0.062	1.279	0.088	1.308
1.219	1.207 – 1.231	0.042	1.293	0.063	1.319	0.089	1.340
1.250	1.237 – 1.263	0.042	1.325	0.063	1.351	0.089	1.381
1.320	1.307 – 1.333	0.043	1.397	0.064	1.423	0.091	1.453
1.400	1.386 – 1.414	0.044	1.479	0.066	1.506	0.093	1.535
1.500	1.485 – 1.515	0.045	1.581	0.067	1.608	0.094	1.638
1.600	1.584 – 1.616	0.046	1.683	0.068	1.711	0.096	1.741
1.626	1.610 – 1.642	0.047	1.770	0.069	1.738	0.097	1.768
1.700	1.683 – 1.717	0.047	1.785	0.069	1.813	0.097	1.844
1.800	1.782 – 1.818	0.048	1.888	0.071	1.916	0.099	1.947
1.900	1.881 – 1.919	0.049	1.990	0.072	2.018	0.100	2.049
2.000	1.980 – 2.020	0.049	2.092	0.072	2.120	0.101	2.152
2.120	2.099 – 2.141	0.050	2.214	0.074	2.243	0.103	2.275
2.240	2.218 – 2.262	0.051	2.336	0.075	2.366	0.104	2.398
2.360	2.336 – 2.384	0.051	2.459	0.076	2.488	0.105	2.522
2.500	2.475 – 2.525	0.052	2.601	0.077	2.631	0.107	2.665
2.650	2.623 – 2.677	0.053	2.754	0.078	2.784	0.108	2.819
2.800	2.772 – 2.828	0.054	2.907	0.080	2.938	0.100	2.972
3.000	2.970 – 3.030	0.055	3.110	0.081	3.142	0.112	3.176
3.150	3.118 – 3.182	0.056	3.263	0.082	3.294	0.113	3.330
3.245	3.211 – 3.279	0.057	3.359	0.083	3.392	0.115	3.428
3.350	3.316 – 3.384	0.057	3.466	0.083	3.498	0.115	3.534
3.550	3.514 – 3.586	0.058	3.670	0.085	3.702	0.117	3.738
3.660	3.622 – 3.698	0.059	3.781	0.086	3.814	0.118	3.851

Table: C (R1)

ELONGATION AND SPRINGINESS FOR ENAMELLED ROUND WINDING WIRES (COPPER WIRES)

Wire Size		Elongation to Break %	Springback Test Method		Springback Requirements (degrees) According to IS:4800				
					Parts IV, V, VI, VII, IX, XI			Part X	
SWG	mm		Mandrel Diameter mm	Tension N	Fine Covering	Medium Covering	Thick Covering	Fine Covering	Medium Covering
11	2.946	34							
12	2.642	34							
13	2.337	33							
14	2.032	33							
15	1.829	32							
16	1.626	32	50	15	28	30	32	30	32
17	1.422	32			32	34	36	34	36
18	1.219	31			36	38	40	38	40
19	1.016	30	50	15	42	45	47	45	47
20	0.914	29			45	48	51	48	51
21	0.813	28			41	43	46	43	46
22	0.711	28	37.5	12	44	47	50	47	50
23	0.610	27			46	50	53	50	53
24	0.559	26			41	44	48	44	48
25	0.508	25	25	8	43	47	51	47	51
26	0.457	25			44	48	53	48	53
27	0.417	24			45	50	55	50	55
28	0.376	23	19	4	47	52	57	52	58
29	0.345	23			48	53	59	53	59
30	0.315	23			50	55	62	55	62
31	0.295	22			46	52	60	52	60
32	0.274	22	12.5	2	47	53	61	53	61
33	0.254	22			49	56	65	56	65
34	0.234	21			50	58	67	58	67
35	0.213	21			53	61	71	61	71
36	0.193	21	10	1	54	62	72	62	72
37	0.173	20			57	65	75	65	75
38	0.152	19			59	67	78	67	78
39	0.132	18			60	68	80	68	80
40	0.122	17	7	0.5	62	70	84	70	84
41	0.112	17			64	73	88	73	88
42	0.102	16			64	73	90	73	88
43	0.091	15	5	0.25	67	77	94	77	92
44	0.081	14			70	80	100	80	96
45	0.071	13			65	77		77	95
46	0.061	12	3	0.10	68	82		82	102
47	0.051	10			72	87		87	110
48	0.041	9							

PEEL TEST
FOR
ENAMELLED ROUND COPPER WINDING WIRES
TO
IS:4800

Nominal wire size				Load	Peel Value Minimum Revolution (n) for enamelled copper wires					
Over mm	Upto including mm	From SWG	Upto including SWG	N	Part IV	Part V		Part VI	Part IX	Part X		Part XI
						Type 1	Type 2 ①			Type A ②	Type B ③	
1.000	1.400	19	18	25	Enamelled wires with high mechanical properties (e.g. PVF wires)	Enamelled wires with temperature index 155 (e.g. Polyester wires)		Enamelled wires with self fluxing properties (e.g. Polyurethane wires)	Enamelled wires with temperature index 180 (e.g. Polysterimide wires)	Enamelled wires with self bonding properties (e.g. Phenoxy over coated PVF or Polyurethane wires)		Enamelled wires with temperature index 220 (e.g. Polyimide wires)
1.400	1.800	17	16	40								
1.800	2.240	15	14	60								
2.240	2.800	13	12	100	$n = \frac{175}{d\ (mm)}$	$n = \frac{150}{d\ (mm)}$	$n = \frac{130}{d\ (mm)}$	$n = \frac{150}{d\ (mm)}$	$n = \frac{110}{d\ (mm)}$	$n = \frac{175}{d\ (mm)}$	$n = \frac{150}{d\ (mm)}$	$n = \frac{90}{d\ (mm)}$
2.800	3.550	11	10	160								

Notes : ① Type 2 wires are with improved heat shock property.
② Type A Heatbonding wires with high mech. properties (e.g. phenoxy overcoat + PVF base coat)
③ Type B Heat bonding wires with self fluxing properties (e.g. Phenoxy overcoat + Polyurethane Base coat)

Table-E (R1)

CUT THROUGH TEST FOR ENAMELLED ROUND WINDING WIRES

Nominal Diameter mm				Load		Speci-men Loading	Time for Insertion Until Loading	Temperature °C (2 min. withstand) Requirement according to IS:4800						
mm		SWG						Part IV	Part V	Part VI	Part VII	Part IX	Part X	Part XI
From	Upto	From	Upto	Copper Wires g (N)	Aluminium Wires g (N)			1	2	3	4	5	6	7
	0.032		49	25 (0.25)		P	1	Wires with high mechanical Properties (e.g. PVF Wires)	Wires with Tempera-ture Index 155 (e.g. Polyester Wires)	Wires with self fluxing properties (e.g. Poly-urethane Wiras)	Wires with good dielectric properties under humid conditions (e.g. Oleo-resinous Wires)	Wires with Tempera-ture Index 180 (e.g. Poly-esterimide Wires)	Wires with Self Bonding properties (e.g. Phen-oxy over coated Polyureth-ane or PVF Wires)	Wires with Tempera-ture Index 220 (e.g. Polyimide Wires)
0.033	0.050		48	41 (0.40)										
0.051	0.080	47	45	71 (0.70)										
0.081	0.125	44	40	128 (1.25)										
1.126	0.200	39	36	224 (2.20)	146 (1.43)									
0.201	0.315	35	30	224 (2.20)	146 (1.43)	P	1							
0.316	0.500	29	26	459 (4.50)	298 (2.92)									
0.501	0.800	25	22	918 (9.00)	597 (5.85)			170	240	170	140	265	170	350
0.801	1.000	21	20	1836 (18.0)	1193 (11.7)									
1.001	1.250	19	18	1836 (18.0)	1193 (11.7)		2							
1.251	2.000	17	15	3672 (36.0)	2387 (23.4)									
2.001	3.000	14	11	7140 (70.0)	4641 (45.50)		3							

Table: F (R1)

ABRASION RESISTANCE TEST FOR ENAMELLED ROUND WINDING WIRES

Nominal Diameter		Abrasion Load										Abrasion requirement strokes according to IS:4900
		Copper wires						Aluminium wires				
		Fine covering		Medium covering		Thick covering		Fine covering		Medium covering		
mm	SWG	g	N	g	N	g	N	g	N	g	N	
0.250	33 & 32	163	1.6	204	2.0	265	2.6	102	1.0	133	1.3	Part IV Wires with high mechanical properties (e.g. PVF Wires) av. : 50 min. : 20
0.280	31	173	1.7	224	2.2	286	2.8	112	1.1	143	1.4	
0.315	30 & 29	194	1.9	245	2.4	306	3.0	122	1.2	163	1.6	
0.355	28	214	2.1	275	2.7	337	3.3	143	1.4	183	1.8	
0.400	27	235	2.3	296	2.9	367	3.6	153	1.5	194	1.9	
0.450	26	265	2.6	326	3.2	398	3.9	173	1.7	214	2.1	Part V Wires with Temperature Index 155 (e.g. Polyester Wires) av. : 40 min. : 16
0.500	25	275	2.7	347	3.4	428	4.2	184	1.8	224	2.2	
0.560	24	306	3.0	377	3.7	469	4.6	204	2.0	245	2.4	
0.630	23	326	3.2	408	4.0	500	4.9	214	2.1	265	2.6	
0.710	22	357	3.5	449	4.4	551	5.4	235	2.3	296	2.9	
0.750		377	3.7	479	4.7	581	5.7	245	2.4	306	3.0	Part VI Wires with self-fluxing properties (e.g. Polyurethane Wires) av. : 30 min. : 12
0.800	21	388	3.8	500	4.9	612	6.0	255	2.5	326	3.2	
0.850		408	4.0	520	5.1	632	6.2	265	2.6	337	3.3	
0.900	20	428	4.2	541	5.3	663	6.5	275	2.7	347	3.4	
0.950		449	4.4	561	5.5	683	6.7	296	2.9	357	3.6	
1.000	19	459	4.5	581	5.7	714	7.0	296	2.9	377	3.7	
1.060		479	4.7	602	5.9	734	7.2	306	3.0	388	3.8	Part IX Wires with Temperature Index 180 (e.g. Polyesterimide Wires) av. : 40 min. : 16
1.120		500	4.9	622	6.1	765	7.5	326	3.2	408	4.0	
1.180	18	520	5.1	643	6.3	785	7.7	337	3.3	418	4.1	
1.250		541	5.3	673	6.6	816	8.0	347	3.4	439	4.3	
1.320		561	5.5	694	6.8	847	8.3	367	3.6	449	4.4	
1.400	17	581	5.7	724	7.1	877	8.6	377	3.7	469	4.6	
1.500		612	6.0	755	7.4	918	9.0	398	3.9	490	4.8	
1.600	16	632	6.2	785	7.7	959	9.4	408	4.0	510	5.0	
1.700		663	6.5	816	8.0	1000	9.8	428	4.2	530	5.2	
1.800	15	694	6.8	847	8.3	1030	10.1	449	4.4	551	5.4	
		694	6.8	847	8.3	1030	10.1	449	4.4	551	5.4	Part XI Wires with Temperature Index 220 (e.g. Polyimide Wires) av. : 20 min. : 8
	14	694	6.8	847	8.3	1030	10.1	449	4.4	551	5.4	
		694	6.8	847	8.3	1030	10.1	449	4.4	551	5.4	
	13	694	6.8	847	8.3	1030	10.1	449	4.4	551	5.4	
		694	6.8	847	8.3	1030	10.1	449	4.4	561	5.5	
	12	694	6.8	847	8.3	1030	10.1	449	4.4	561	5.5	

Table . G

BREAK DOWN VOLTAGE FOR ENAMELLED ROUND WINDING WIRES ①

Nominal Diameter mm Over	Nominal Diameter mm Upto & including	Nominal Diameter SWG	Test Specimen Confugeration	Test Specimen preparation: Total Tension on Wire twist Copper g (N)	Test Specimen preparation: Total Tension on Wire twist Aluminium g (N)	Test Specimen preparation: twists per 125 mm	Break down voltage, minimum volts at Room Temp. ②: Fine	Break down voltage, minimum volts at Room Temp. ②: Medium	Break down voltage, minimum volts at Room Temp. ②: Thick ③
0.040	0.050	48					350	700	
0.050	0.063	47 & 46	twist pair	20 (0.2)		40	400	800	
0.063	0.070						500	950	
0.070	0.080	45					500	950	1400
0.080	0.100	44	twist pair	41 (0.40)		40	600	1200	1600
0.100	0.110	42					700	1300	1800
0.110	0.125	41 & 40					700	1300	1800
0.125	0.160	39 & 38	twist pair	87 (0.85)	56 (0.55)	33	800	1500	2200
0.160	0.200	37 & 36					900	1700	2500
0.200	0.250	35 & 34					1000	2000	3000
0.250	0.315	33 to 30		173 (1.70)	112 (1.10)	23	1200	2200	3300
0.315	0.350	29					1400	2400	3700
0.350	0.400	28	twist pair	347 (3.40)	225 (2.21)	16	1400	2400	3700
0.400	0.500	27 & 26					1600	2800	4000
0.500	0.710	25 to 23		714 (7.00)	464 (4.55)	12	1800	3100	4400
0.710	0.750	22					1900	3500	4700
0.750	0.850	21					1900	3500	4700
0.850	0.950	20	twist pair	1377 13.50	896 8.78	8	2000	3700	5100
0.950	1.050	19					2100	3800	5300
1.050	1.120						2100	3800	5300
1.120	1.320	18	twist pair	2754 (27.00)	1790 (17.55)	6	2200	3900	5600
1.320	1.500	17					2300	4000	5900
1.500	1.600	16					2300	4000	5900
1.600	1.900	14	twist pair	5508 (54)	3580 (35.1)	4	2400	4300	6100
1.900	2.150						2500	4400	6300
2.150	2.500	13	twist pair	11016 (108)	7160 (70.2)	3	2500	4400	6300
Over 2.500		12 & thicker	Aluminium foil wrapped wire				1000	1600	2400

Notes : ① Break down voltage values are for all types of wires.

② Break down voltage requirement at Thermal Class temperature are min 75 percent of BDV specified at RT

③ Thick covering is applicable to Wires with high mechanical properties (e. g. wires coated with Poly Vinyl Formal enamel) only.

Flexibility and Adherence
Mandrel Winding Test Requirements
For Enamelled Round Winding Wires
To
IS 4800

Nominal Wire Size				Mandrel Winding Test Requirements				
				Part IV Wires with high mech. properties e.g. PVF wires Part V wires with TI 155 e.g. polyester wires Part VI wires with self fluxing property e.g. polyurethane wires Part IX wires with TI 180 e.g. polyesterimide wires	Part VII wires with good dielectric properties under humid conditions		Part X wires with heat bonding property e.g. phenoxy over coated PVF or Polyurethane wires	Part XI wires with TI 220 e.g. polyimide wires
Over (mm)	Upto including (mm)	From (SWG)	Upto including (SWG)		Copper	Aluminium		
0.050	0.250	47	34	1d	1d	10d	1d	20% stretch + 3d
0.250	1.000	33	20	1d	1d	10d	1d	1d
1.000	1.600	19	17	1d			1d	1d
1.600	2.000	16	15	32% (Linear stretching)			32%	
2.000	5.000	14		32%			32%	

Notes: 1) Definition of crack — A discontinuity in the enamel film exposing the conductor surface
2) crack observation — The specimen should be examined for cracks under magnification 6 to 10 times.

Heat Shock Test
For
Enamelled Round Winding Wires
To
IS 4800

Nominal Wire size				Mandrel Winding Requirements for Heat Shock									
(mm)		(SWG)		Part IV and Part X type A & B wires with high mechanical properties e.g. PVF wires		Part V wires with TI 155 e.g. polyester wires				Part VI wires with self-fluxing property e.g. polyurethane wires	Part VII wires with good dielectric properties under humid conditions		Part IX wires with TI 180 e.g. polyesterimide wires	Part XI wires with TI 220 e.g. polyimide wires
over	upto including	From	upto including			Copper		Aluminium						
				Copper	Aluminium	Type 1	Type 2	Type 1	Type 2		Copper	Aluminium		
Heat Shock Temperature °C				155-160		175-180				125-130	125-130		195-200	240-250
0.050	0.160	48	38	1d*	3d*	5d	3d*			3d*	4d	10d	3d*	3d*
0.160	0.250	37	34	1d*	3d*	5d	4d*	5d	4d*	4d*	4d	10d	4d*	3d*
0.250	0.500	33	26	1d	2d	6d	2d	6d	2d	2d	4d	10d	2d	1d
0.500	1.000	25	20	1d	2d	6d	2d	6d	2d	2d	5d	10d	2d	1d
1.000	1.600	19	17	1d	2d	7d	3d	7d	3d	3d	5d	10d	3d	1d
1.600	2.000	16	15	32%		10%	20%						25%	
2.000	5.000	14		32%		10%	20%						25%	

* The wire shall be stretched 20% in case of copper & 15% in case of aluminium before winding on mandrel.

Notes 1. The specimen should be examined for cracks under magnification 6 to 10 times

2. Defination of crack — A discontinuity in the enamel film, which exposes the conductor surface, when viewed at magnification 6 -10X

Table : J

Annex 3
Page 14

HEAT BONDING TEST
METHOD AND REQUIREMENTS FOR ENAMELLED ROUND WINDING WIRES TO IS:4800 (PART X)

Nominal wire size (mm) Over	Upto & including	Nominal wire size (SWG) From	Upto & including	Specimen Preparation: Mandrel Diameter (mm)	Specimen Preparation: Load on coil during bonding (N)	Temperature & Time during bonding (°C)	Bond strength Test requirement minimum (N)
0.050	0.071	47	45	1	0.050	170 ½h	0.05
0.071	0.100	44	43	1	0.050		0.08
0.100	0.160	42	38	1	0.150		0.12
0.160	0.200	37	36	1	0.250		0.25
0.200	0.315	35	30	2	0.350		0.35
0.315	0.400	29	28	3	0.500		0.70
0.400	0.500	27	26	4	0.750		1.10
0.500	0.630	25	23	5	1.250		1.60
0.630	0.710			6	1.750		2.20
0.710	0.800	22	22	7	2.000	170 1h	2.80
0.800	0.900	21	21	8	2.500		3.40
0.900	1.000	20	20	9	3.250		4.20
1.000	1.120	19	19	10	4.000		5.00
1.120	1.250	19	18	11	4.500		5.80
1.250	1.400			12	5.500		6.30
1.400	1.600	17	17	14	6.500		8.50
1.600	1.800	16	16	16	8.000		10.50
1.800		15		18	10.000		10.50

UNIDIRECTIONAL SCRAPE RESISTANCE TEST FOR ENAMELLED ROUND WINDING WIRES (COPPER) TO IS:4800 (PART IV) WIRES WITH HIGH MECHANICAL PROPERTIES (e.g. PVA)

Nominal Diameter		Fine Covering		Medium Covering		Thick Covering	
mm	SWG	Minimum Force to Failure (N)	Average Force to Failure (N)	Minimum Force to Failure (N)	Average Force to Failure (N)	Minimum Force to Failure (N)	Average Force to Failure (N)
0.250	33 & 32	2.55	3.00	3.00	4.15	4.90	4.90
0.250	33 & 32	2.55	3.00	4.15	4.90	4.90	5.80
0.280	31	2.75	3.25	4.45	5.25	5.30	6.25
0.315	30 & 29	2.95	3.50	4.80	5.65	5.70	6.70
0.355	28	3.20	3.75	5.15	6.05	6.10	7.20
0.400	27	3.45	4.05	5.50	6.50	6.50	7.70
0.450	26	3.70	4.35	5.90	7.00	7.00	7.00
0.500	25	3.95	4.65	6.35	7.50	7.50	8.85
0.560	24	4.25	5.00	6.80	8.00	8.05	9.50
0.630	23	4.55	5.35	7.30	8.60	8.65	10.20
0.710	22	4.85	5.70	7.80	9.20	9.25	10.90
0.750		5.00	5.90	8.10	9.55	9.55	11.3
0.800	21	5.15	6.10	8.40	9.90	9.90	11.7
0.850		5.35	6.30	8.70	10.20	10.20	12.1
0.900	20	5.55	6.55	9.00	10.60	10.60	12.5
0.950		5.75	6.80	9.30	10.90	10.90	12.9
1.000	19	5.95	7.05	9.60	11.30	11.30	13.3
1.060		6.20	7.30	9.90	11.7	11.6	13.7
1.120		6.45	7.60	10.20	12.1	12.0	14.2
1.180	18	6.70	7.90	10.60	12.5	12.5	14.7
1.250		6.95	8.20	11.00	12.9	12.9	15.2
1.320		7.20	8.50	11.40	13.4	13.4	15.8
1.400	17	7.45	8.80	11.8	13.9	13.9	16.4
1.500		7.45	8.80	11.8	13.9	13.9	16.4
1.500		7.70	9.10	12.2	14.4	14.4	17.0
1.600	16	8.00	9.45	12.6	14.9	14.9	17.6
1.700		8.30	9.80	13.1	15.4	15.4	18.2
1.800	15	8.60	10.10	13.5	16.0	16.0	18.8
1.900		8.90	10.50	14.0	16.5	16.5	19.5
2.000	14	9.20	10.90	14.4	17.1	17.1	20.2
2.120		9.55	11.30	14.9	17.6	17.7	20.9
2.240	13	9.90	11.70	15.4	18.2	18.3	21.6
2.360		10.20	12.10	15.9	18.8	13.9	22.3
2.500	12	10.60	12.50	16.4	19.4	19.5	23.0

Note 1 Load (initial) selected should be $\leq$ 90% of the minimum force to failure.

2 Force to failure is calculated as Newtons to fail – Load (initial) in N × distance travelled untill failure (marking on lever)

3 1N = 102 g

Table K(2)

UNIDIRECTIONAL SCRAPE ABRASION TEST FOR ENAMELLED ROUND WINDING WIRES (COPPER) TO IS 4800

Nominal Diameter		Part V Wires with TI 155 e.g. Polyester wires				Part VI Wire with self fluxing property e.g. Polyurethane wires				Part IX Wires with TI 180 e.g. Polyesterimide wires			
		Fine		Medium		Fine		Medium		Fine		Medium	
mm	SWG	min. (N)	av. (N)	min. (N)	av. (N)	min. (N)	av. (N)	min. (N)	av. (N)	min. (N)	av. (N)	min. (N)	av. (N)
0.250	33 & 32	2.30	2.70	3.80	4.50	1.95	2.30	3.50	4.10	2.45	2.85	4.00	4.70
0.280	31	2.45	2.90	4.10	4.80	2.10	2.50	3.70	4.40	2.60	3.10	4.30	5.05
0.315	30 & 29	2.65	3.15	4.40	5.20	2.30	2.70	4.00	4.75	2.80	3.35	4.60	5.45
0.355	28	2.85	3.40	4.75	5.60	2.50	2.90	4.30	5.10	3.05	3.60	4.95	5.85
0.400	27	3.05	3.65	5.10	6.00	2.70	3.15	4.60	5.45	3.25	3.85	5.30	6.25
0.450	26	3.30	3.90	5.45	6.45	2.90	3.40	4.90	6.00	3.50	4.15	5.70	6.75
0.500	25	3.55	4.20	5.85	6.90	3.10	3.65	5.25	6.20	3.75	4.45	6.10	7.20
0.560	24	3.80	4.50	6.25	7.40	3.30	3.90	5.60	6.65	4.05	4.75	6.50	7.70
0.630	23	4.10	4.85	6.70	7.90	3.55	4.20	6.00	7.10	4.35	5.10	7.00	8.25
0.710	22	4.40	5.20	7.20	8.50	3.80	4.50	6.45	7.60	4.65	5.45	7.50	8.85
0.750		4.55	5.45	7.45	8.80	3.95	4.65	6.65	7.85	4.80	5.65	7.80	9.20
0.800	21	4.70	5.60	7.70	9.10	4.10	4.80	6.90	8.10	4.95	5.85	8.05	9.50
0.850		4.90	5.80	7.95	9.40	4.25	5.00	7.15	8.40	5.15	6.05	8.30	9.80
0.900	20	5.10	6.05	8.20	9.70	4.40	5.20	7.40	8.70	5.35	6.30	8.60	10.20
0.950		5.30	6.30	8.50	10.00	4.55	5.40	7.65	9.00	5.55	6.55	8.90	10.50
1.000	19	5.50	6.55	8.80	10.40	4.75	5.60	7.90	9.30	5.75	6.75	9.20	10.90
1.060		5.70	6.80	9.10	10.70	4.95	5.80	8.20	9.65	5.95	7.05	9.50	11.20
11.20		5.95	7.05	9.40	11.10	5.15	6.00	8.50	10.00	6.20	7.35	9.80	11.60
1.180	18	6.20	7.30	9.70	11.50	5.35	6.25	8.80	10.30	6.45	7.60	10.20	12.00
1.250		6.45	7.60	10.00	11.90	5.55	6.50	9.10	10.70	6.70	7.90	10.50	12.50
1.320		6.70	7.90	10.40	12.30	5.75	6.75	9.40	11.00	6.95	8.20	10.90	12.90
1.400	17	6.95	8.20	10.80	12.70	5.95	7.00	9.70	11.40	7.20	8.50	11.30	13.30
1.500		7.25	8.55	11.20	13.20	6.15	7.25	10.00	11.80	7.50	8.85	11.70	13.80
1.600	16	7.55	8.90	11.60	13.70	6.35	7.50	10.40	12.20	7.80	9.20	12.10	14.30
1.700		7.85	9.25	12.00	14.20	6.55	7.75	10.70	12.70	8.10	9.65	12.60	14.80
1.800	15	8.15	9.60	12.40	14.70	6.80	8.00	11.00	13.10	8.40	9.95	13.00	15.40
1.900		8.45	9.95	12.80	15.20	7.05	8.30	11.50	13.60	8.70	10.20	13.4	15.9
2.000	14	8.75	10.30	13.30	15.70	7.30	8.60	11.90	14.00	9.00	10.60	13.9	16.4
2.120		9.05	10.70	13.70	16.20	7.60	8.95	12.30	14.50	9.30	11.00	14.3	16.9
2.240	13	9.40	11.10	14.20	16.70	7.90	9.30	12.70	14.90	9.65	11.40	14.8	17.5
2.360		9.75	11.50	14.60	17.20	8.20	9.65	13.10	15.40	10.00	11.80	15.3	18.0
2.500	12	10.10	11.90	15.10	17.80	8.50	10.00	13.50	15.90	10.40	12.20	15.8	18.6

Note — 1 Load selected should be ≤ 90% of the minimum force to failure
2 Force to failure is calculated as Newtone to Fail =
Load (initial) in N X distance travelled untill failure (marking on lever)
3 1N ≒ 102 g

Table L

SOME COMMON DEFECTS AND THEIR CAUSES FOR ENAMELLED ROUND WINDING WIRES

DEFECT	CAUSE
Colour variation, dullness, coloured patches	• Oven temperature variation, misalignment of wires in the oven • Oxidized wire, traces of annealing water and wire drawing lubricants present • Improper pickling-presence of pickling acid traces, pickling incomplete, anti-tarnishing treatment not done • Enamel coating eccentric, variation in build up • Enamel + thinner mixture non-homogenous, crystallization of enamel • Enamelling speed variation • Improper exhaust conditions
Roughness, black spots, excess enamel spots	• Copper conductor surface rough (fins-flakes-slivers-dielines) • Dust from atmospheric air • Solid deposits from oven,exhaust cleaning needed • Vibrations during enamelling • Damage due to defective sheaves • Wire enamel flow improper, contaminated wire enamel, refilteration required
Blisters	• Incorrect temperature profile • Too high enamel build-up in initial or any subsequent pass • Too much or incorrect thinner used
Low elongation, High springiness, (hard wire)	• Insufficient preannealing temperature • Less number of passes • Low oven temperature,high enamelling speed • Bad copper
Excessive pin-holes	• Presence of copper dust due to improper pickling (washing with pressure jet essential) • Bad copper
Loose winding	• Insufficient and varying winding tension • Improper traverse movement • Poor quality spools

ANNEX 4

NAMES AND ADDRESSES OF THE PERSONS VISITED DURING THE MISSION

UNIDO ACCRA

DR. J.M.I. SAIT	Chief Technical Adviser Feasibility Analysis Unit
MR. S. ASARE	Head, Projects Department National Investment Bank, Accra
MR. ANTTI AHONEN	Management Consultant Kauppat Kant UNIDO - Expert on Mission
MR. HENRICK CARLSEN	Director - Dancem UNIDO - Expert on Mission
ING, ADOLF TAUCHMAN	UNIDO - Expert on Mission
Mr. ODDVAR JAKOBSEN	Deputy Resident Representative UNDP

OTHERS

DR CHARLES Y.W. BROBBY	Energy Policy Advisor in the Ministry of Fuel and Power, National Energy Board
NII A-AYITE	Managing Director, Kabel Metal - (A joint-venture Unit of NIB)
MR. D.T. AMAR	Managing Director, Bradbury Manufacture Co. (Ghana) Ltd. and Ravi Co. (Gh.) Ltd.
MR. SEVAK RAM	Managing Director, Ghana Foundry
MR. UPPAL	High Commissioner of India
MR. A.D. AIKINS	Managing Director, Electric Engineering Company
Mr. K.E. Mensah	Managing Director, Nana Apaa Refrigeration and Air Condition Services
MR. SAM A. ABOROSO	Managing Proprietor, Electrico Electric
MR. E.S. YOOFI BOHAM	Managing Director, VETO 09 (1973) Enterprise, General Merchants, Imports and Exports