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

18607

DP/ID/SER.A/1392
26 September 1990
ORIGINAL: ENGLISH

INDUSTRIAL ADVISORY SERVICES AND TRAINING

DP/EGY/88/032

EGYPT

Technical report: Manufacturing and testing of medium tension power cables*

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

Based on the work of M. J. Hölzer,
Consultant in manufacturing and testing of high-voltage power cables

Substantive officer: Mr. Gürkök
Engineering Industries Branch

Backstopping officer: Mr. Koliakine
Section for Integrated Industrial Projects

United Nations Industrial Development Organization
Vienna

---

* Mention of company names and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

V.90-87966

Table of Contents

A B S T R A C T

Post title : CONSULTANT IN MANUFACTURING AND TESTING OF MEDIUM TENSION POWER CABLES

Number of Project : DP/EGY/88/032/11 - 64

Duration : May 2 nd to June 29 th, 1990

Duty Station : Cairo, EGYPT, Electro Cable Egypt (ECE)

Purpose of the Project : To improve quality of cross-linked Polyethylene cable production

Main Conclusions :

1. The basic equipment for the manufacturing and testing of XLPE-insulated medium tension power cables are incomplete. They have to complete in order to secure the existing technique for production and for assurance of quality.
   On the one hand exist modern machines and on the other hand obsoleted equipment

2. The tests of quality (inspection and testing) performed at present concerning incoming material, productionprocess and ready made cable are not sufficient in order to guarantee the quality of final product (including of quality documentation and records).

3. Improvement of qualification for the field of work (quality management - executive and management personnel, technical personnel, production supervisors and workers)

4. In order to increase the quality of XLPE-insulated medium tension power cables the

promt application of the recommendations would be most advisable, although this seems not to be so easy in the actual given economical situation.

Main Recommendations :

1. Completion of basic equipment for the manufacturing and testing of XLPE-insulated medium tension power cables. Further more renewal gradually of the obsoleted equipment. Assurance of systematically maintenance and repair.

2. Production according to VDE o273, tests according to VDE o472 and realization of ISO 9ooo " Quality management and quality assurance standards:Guidelines for selection and use " 1987-o3-15

3. Requirement of experts:
   a) Expert for manufacturing and testing of XLPE-insulated medium/high - voltage power cables. That expert must be a high qualified electrical engineer and should have at least five years of experience.

   b) Expert for manufacturing of conductors for medium/high - voltage power cables and maintenance for the production equipment. It is recommended that this expert is a high qualified mechanical engeneer and should have at least five years of experience in cable plant maintenance.

   c) Expert for management and economy in the manufacturing of medium/high - voltage power cables.

The experts have also to train the executive and management personnel and to give consul-

tations.
The duration of the experts should be at least six month in order to get a good result for longer time and to have a possibility to find all kinds of problems and to make training with operators.

4. It is recommend to introduce daily " down time reports " and to analyse every week/month the production - down times, quality, maintenance and all problems concerning the medium tension power cables with a final monthly report made by production manager.

I N T R O D U C T I O N

According to the Job Deseription DP/EGY/88/o32/11 - 64, the purpose of the project was to improve the quality of cross-linked polyethylene cable production at Eletro Cable Egypt Co. (ECE).
The consultant's mission at the ECE lasted from May 5 th to June 27 th, 199o.

The consultant had the following duties:

1. Apprise himself of the types of power cable which are produced locally, equipment used, testing capacities.

2. To assist in the introduction of new technology for the manufacture of XLPE insulated medium tension power cables.

3. To recommend to reduce losses in production processes.

4. To assist in the introduction of new testing techniques according to international standards.

5. To provide on-the-job training for production and testing staff of the Electric Cable Company.

6. To prepare an analyses on the expected problems and their trouble shooting in both production and testing stages.

7. To prepare a report summarizing results of his mission and selting-up recommendations concerning the above subject. Prior to the completion of this mission, the expert will also be expected to discuss his findings and recommendations with the counterpart and the Government.

The main activities of the consultant to perform the foreseen project, were:

1. Tests of materials according to the applied standards
1.1. Aluminium - and Copper - wires and Cu - foil

1.2. Polyethylene and catalyst
1.3. Semiconductive material and semiconductive tape

2. Analysis of the production process
2.1. Wire drawing
2.2. Conductor stranding
2.3. Insulation
2.4. Curing process
2.5. Copper screening
2.6. Core laying
2.7. Filling and armouring
2.8. Outer sheathing

3. Tests of the ready made cable
3.1. Hot-Set-Test
3.2. Partial discharge test
3.3. High-tension-test
3.4. Checking the three layer thickness and the risistance

4. Minimizing of scrap

5. Weekly consultations to the above mentioned points

I. A C T I V I T I E S

- Based on the Job Description is was assumed that dry curing lines are existing in ECE. But they use the Siloxane bridge curing it means Sioplas process. This method is unusual for the manufacturing of XLPE-insulated medium tension power cables. Normaly this method is used for the production of low tension power cables.
  The condition of the technical equipment is not satisfactory for the manufacturing and curing of XLPE-insulated cables, e.g. the exactly measuring and recording of temperature during the curing process was not possible.

- Tests of the incoming material were carried out. But moisture content tests and pollution content tests of the material (PE, semiconductiv material, catalyst) were neglected because the equipment were not available.

- For the manufacturing of wires and conductors (compacting) were used dies (angles and polishing) which were not fited for a good quality of medium tension power cables.
  On the other hand modern machines were used for the manufacturing of conductors, including welding equipment (cold-process).

- The extruder-lines work not synchronous enough. The consequence is the tolerance of the wall thickness of insulation according to the standard (min./max.) is not guaranteed (see test results in annex 3).

- The tests of crosslinking (hot-set-test) were not carried out continnous because the needed equipment were not all available.
  Analysises of these tests are missing.

- Partial discharge tests were carried out on single cores and ready made cables and also the results were documented.
  Conditioned by that existent situation the consultant undertook with the cable manufacturer (ECE) the following activities to the focal points:

1. Changes of draw-angles and surface-poloshing of the dies.

2. Carrying-out of moisture content measurements by weight changing.

3. Carrying-out of crosslinking tests (hot-set-tests) of the incoming material under laboratory conditions and of samples from the present production.
   The producing samples were carried out with simple equipment by hand.

4. On the grounds of insufficient results of hot-set-tests were caused:
   a) Tests of material
   b) Checks of temperatures
   c) Control of crosslinking process

5. Control of partial discharge tests and guidance to a higher accuracy of measurements.

6. Check of high tension tests.

7. Fault-analyses of ready made cables.

II. C O N C L U S I O N S

The principal findings are written under the point main conclusion.
In addition there are the following points:

1. The manufacture of XLPE-insulated medium tension cables demand much more cleanness and order.

2. The process of crosslinking and the partial discharge tests have to be carried out more controled.

3. The experts which mentioned in the main recommendations are necessary in order to give an effective help to ECE in technique, production and economy.

4. Manager of ECE ask several times the consultant if the presuppositions of manufacture of 66 KV-XLPE-insulated cables are existent.
   At present it is sure that the required conditions for this production are not exist.

III. R E C O M M E N D A T I O N S

1. The principal recommendations are written under the point main recommendation.

2. Extension of denotation of the medium tension cables according to the standard.
   For example N2XS2Y 1 x 24o RM/25 18/3o KV (acc. to VDE)

3. Use of a closed pipesystem for the transport of granulat for medium tension cable production (box - drier - extruder for XLPE, semiconductive material and catalyst)

4. Drying of XLPE - material and catalyst

5. Use of exact synchronized extruder lines

6. Production of super cleanly conductor (free of metal chips, dust, oil, grease)

7. Assurance of curing and observance of partial discharges limit

8. Use of recommended test-standards for incoming material, manufacture and final test of cables (see annex 2).

9. Introduction of a training-system for qualification on place of employment

1o. Delimitation of responsibility in the production process under the consideration of wage payment in dependence upon the achievements and quality.

11. Minimizing of scrap
    - Control of quantity of input material
    - Calculation of scrap conditioned by the technology (standard scrap)
    - Record of faulty production based on the steps of manufacture
    - Use of an efficient technology
    - Good conditions of machines and equipment

12. Weekly elaboration and evaluation of fault-analyses

IV. A N N E X E S

Annex 1 : - Work Programme of the expert

- Procedure for the technical cooperation bet ween the ECE and the expert

Programme of the expert

Post title	:	Consultant in manufacturing and testing of medium tension power cables
Name of expert	:	M. J. Hölzer
Post key code	:	DP/EGY/88/032/11 - 64
Duration	:	59 days / 02.05. 1990 - 29.06. 1990
Duty station	:	Electro Cable Egypt (ECE), Cairo, EGYPT

02. - 04.05.90	Travel to Vienna and briefing at UNIDO
05.05.90	Arrival to Amman
06.05.90	Introduction at UNDP and ECE in Cairo
07.05.90	Introduction to management at ECE and general discussions
08. - 09.05.90	General inspection of the XLPE-insulated medium tension power cables and test-methods
10. - 16.05.90	Tests of materials to the applied standards in the laboratory
17. - 19.05.90	Drawing of wires
20. - 21.05.90	Conductor stranding
22. - 04.06.90	Insulation
05. - 08.06.90	Curing process
09. - 11.06.90	Copper screening
12. - 13.06.90	Core laying
14. - 17.06.90	Filling and armouring
18. - 19.06.90	Outer sheathing
20. - 24.06.90	Test of the ready made cable
25. - 27.06.90	Final discussions with the management concerning report conclusions and recommendations Departure from ECE
28.06.90	Departure for Vienna
29.06.90	Debriefing at UNIDO in Vienna
30.06.90	Leave of Vienna

Date : o8.o5. 199o
Subject : Procedure for the technical cooperation between Mr. Hölzer the UNIDO representative and ECE during the period o5.o5. 199o and 28.o5. 199o

Attendant : Mr. Hölzer
Mr. Iskander Fahmy
Mr. Ragal Awadallah
Mr. Ahmed Yousef

Coppies to : Mr. Hassan Helmy ECE President
Mr. M. A. Khalil ECE ECE Factories sectors director

Technical cooperation between Mr. Hölzer the UNIDO expert and ECE staff will be performed during the period o5.o5. 199o up to 28.o6. 199o through the following subjects concerning the medium tension cables manufaturing and testing in ECE factories.

1. Control of the incoming raw materials production during processes and finished cables testing.

2. Minimizing of scrap.

3. Minimizing of size changing for the sake of maximum productivity.

4. Suitable product mix for the available equipment capabilities.

5. One degree quality for Exportation and local consumers.

6. Equipment quality level should be able to produce quality levels.

7. M/Cs effeviency.

8. M/Cs and processes capacity to minimize bottle necks.

9. Production flow measures, and quality control reports to be submitted tothe management.

1o. Labbling in the production floor for each cable length.

11. Minimizing of the maintenance and repair costs.

12. Plans for preventive maintenance.

13. Operators training and skils.

14. Hospital cleanliness in all production processes.

15. Security of the operations

Mr. Hölzer will check the medium tension cable processes starting by the drawing process ending with finished cable testing and will concerntrat on the areas needing technical assistance.

Weekly meetings attended by concerned staff will be necessary.

Paper recived: Copy of ISO 9ooo

Annex 2 :

- Recommendations resulting from the period of May 5 th to June 5 th
- Seven protocols about consultations
- Recommended standards
- Recommended equipment

o5/o5 ..... o5/o6/9o

Recommendations for increasing the quality of XLPE-cables in ECE per o5/o6/ 199o

1. Equipment for testing the incoming material and procedure

1.1. Equipment for preparing the dumb-bell pieces (hot-set-test) and slices (measure of thickness)

1.2. Plasti-Corder 33o of the company BRABENDER, Duisburg, W.-Germany for tests of purity of compounds (XLPE)

1.3. Microscopt with measurement reading for counting the particles of pollution of compound-sheet-samples

1.4. A set weights (o.o1 ... 1o gr.) for moisture test

1.5. Standards for tests: VDE o273; VDE o472; VDE o2o7; VDE o3o3; VDE o295
DIN 53854 ... 57; DIN 53482; DIN 53495; DIN 543o5
ISO/DIS 9o73, IEC 5o2, BS 5468, IEC 54o, ASTM IPCEA S-66-524, D 257, D 19286, D 15o5, D 638, D 756, D 1238, D 2765 A

2. Production process

2.1. Realization of ISO 9ooo "Quality management and quality assurance standards - Guidelines for selection and use" 1987-o3-15

2.2. Use of a closed pipesystem for the transport of granulat for medium tension cable production (box - drier - extruder for XLPE, semiconductive material and catalyst)

2.3. Exact synchronized extruder lines

2.4. Production of super cleanly conductor (free of metal chips, dust, oil, grease)

2.5. Assurance of curing and observance of partial discharges limit

2.6. Production according to VDE o273 and tests acc. to VDE o472

2.7. Production > 3o KV with dry-curing-cv-lines

3. Recommendedexperts

3.1. Expert for manufacturing and testing of medium/high - voltage cables (XLPE)

3.2. Expert for maintenance and manufacturing of conductors

3.3. Expert for management and economy

Date : 09.05. 1990
Subject : First meeting between Mr. Hölzer the UNIDO Representative and ECE

Attendant : Mr. Hölzer
Mr. Iskander Fahmy
Mr. Foaad Khalil
Mr. Ragai Awadallah
Mr. Samir Shouhdy

Copies to : Mr. Hassan Helmy ECE President
Mr. M. A. Khalil ECE Factories Sectors Director

Discusions were on the stranding process of the compasted conductors for MT-cables and handling of the conductors as follows:

1. Cleaning of the bare conductors and it should be free from metal chips.
2. Trying the compaction of the wires during stranding by sucessive dies.
3. Dies should be good finishing with an entrance angle where the compaction should come inside the core of the dies and the wires should be parallel to the core surface of the dies.
4. Special equipment should be used for lubricating the wires during stranding before entrance the dies. Drops of thinner (taken from the enamelleo wires) should be used.
5. Find a circular motorized cloth brush to be installed after the extrusion line inlet caterpiller and before the extrusion head for cleaning the bare conductor.
6. Think about minimizing the polyethelene scrap coming from the intersection of the L type extruders (to be discussed alone).
7. Mr. Hölzer attended the incoming copper and aluminium testing procedure and he has no comments.

Date : 19.o5. 199o
Subject : Second meeting between Mr. Hölzer the UNIDO representative ans ECE

Attendant : Mr. Hölzer
Mr. Iskander Fahmy
Mr. Ragai Awadallah
Mr. Foaad Khalil

Coppies to : Mr. Hassan Helmy ECE President
Mr. M. A. Khalil ECE Factories Sectors Director

Discusions were on the specification of the incorning material and its test in the laboratories and hot-set-test as follows:

1. Copper tape specification: -
   Purity and Resistivity:
   IEC standard statid that the max. value of resistivity of the copper tape should be o.o17241 Ω mm^2/m.
   Mr. Hölzer point of view is that this resistivity connat be reached by purity lower than 99.95 %.
   Also he recommends to follow the IEC 228 only
   i.e, ρ = o.o17241 Ω mm^2/m which belong to purity of 99.95 %.
2. Semi conductive extruded material (incoming materials)
   The following item should be added:
   - Contamination level in the material
     In one kg of material the max. level of contamination should not exceed:
     max. 2o contaminates pieces $\geq$ diameter 5o - 1oo μm
     max. o.5 " " $\geq$ " 1oo - 15o μm
     zero contaminates diameter more than 15o μm
     Equipment: it is advisable to get laboratory extruder from company BRABENDER town Duisburg, W.-germany
   - Humidity:
     Specification should inculde the following:
     humidity 1 ooo ppm (o.1%)
     this can be checked by mitsubishi standard 15o°C or by balance

- Test were made on actual ECE semi-conductor granuals and they show humidity percent as o.o46 - o.o59 % at 5 hrs 5o°C.
  So results are acceptable but ECE should add this item to their specification. This means that after drying for 5 hrs 5o°C ECE can reach o.o2 % max. humidity which is acceptable and suitable for cable manufacturing.
- Supplied granuals should be packed under vacuum and this should be added to ECE specification.
- ECE should made at least one test for each patch.
- Aging: for semi conductor material
  a) variation in tensile strength and elongation % after aging 1o days - 155°C should not be more than 2o%
  b) storage of material temperature should be 1o - 3o°C

3. Insulation material: (incoming material)
   - Break down voltage should be charged to 22KV/mm
   - Max. contamination level:
     In one kg of material the max. level of contamination should not exceed:

max. 3 pieces	$\geq$	diameter 12o - 25o m
max. zero		diameter more than 25o m

   - ECE speci. should be modified for the a/m item
   - Hot-set-test for the incoming material should not be less than 1oo % and the rest elongation 1o %
   - Humidity:
     Max. humidity for the incoming material should be less than o.5 % (5 ooo ppm)
   - Add in the speci. that material should be packed under. Vacuum
     Storage temp. 1o - 2o °C or as recommended by the supplier

4. Semi conductive tape: (incoming material)
   The following speci. should be added:

Surface resistivity	1 5oo Ω/ 5oo cm^2
Volume resistivity (VDE o3o3) max.	4 ooo cm^2
Elongation longitudinally	15% min.
Elongation transeverse	25% min.
Humudity	o.5% max.

5. Catalyst: (incoming material) MAC/1oo crosspolemery
   - Tests were made after drying the catalyst at 5o°C - 5 hrs it gives results for humidity % as o.o18 - o.o24 %
   - Max. acceptable humidity % should be o.1 % for the incoming mat.
   - Max. acceptable humidity % should be o.o2 % before extrusion
   - It is to dry the catalyst before extrusion process.
6. Hot-set-test:
   Hot-set-test in XLPE were done in the laboratories as follows:
   a) 7 tests for XLPE mat. from the production
   b) 8 tests for XLPE mat. from the laboratory
   - Samples were taken from cables as follows:
     three samples from the present production
     two samples were taken from production realized since 14 days
     the balance of the samples which is realized since 3 months.
     All samples failled in the hot-set-test
   c) Samples were made from the laboratory as follows:
      4 samples were prepared 1oo % in the laboratory from the granuals (cured also in the laboratory)
      2 samples were taken from the extrusion m/cs (XLPE mat.) (line 6o/9o/15o) and cured in the laboratory.
      All the six samples passed successfully the hot-set-test
      range of elongation is 7o.1 - 84.oo %
      rest elongation is 5.9 - 8.6 %
      which successfull results as per IEC 54o
      This that the curing process in the factory is not effective.

Mr. Hölzer will concentrate on the curing process to advice the correct process and temperature.
Laboratory needs chipping facility for samples preparation.

Date : 26.o5. 199o
Subject : Third meeting between Mr. Hölzer the UNIDO representative and ECE

Attendant : Mr. Hölzer
Mr. Mohamed A. Khalil
Mr. Iskander Fahmy
Mr. Abdallah Nasr
Mr. Foaad Khalil
Mr. Ragai Awadallah
Mr. Samir Shouhdy

Coppies to : Mr. Hassan Helmy ECE President
Mr. M. A. Khalil ECE Factories Sector Direktor

Discusion were on hot-set-test as IEC specification for MT-cables and the drawing process.

1. Hot-set-test:
   - Mr. Hölzer mentioned that we need equipment to prepare dumball samples.
   - One sample could be taken per chamber having
   - Mr. Hölzer recommended to make a test sheet to record the following data:
     . Date of production, date of test
     . type, cross sectim and tension
     . M/C, shift and material supplier
     . operator name, length and bebbin number
     . curing temperature and curing times
     . tester name and signature
     . hot-set-test results
     . standards IEC 54o/82 or VFC 32 - 321
     or BSS 5468 or VDE o472
     from IEC 54o/82 condition: 2oo^{o}C 15 min. lod 2o N/cm^{2}
     'IEC 5o2/83
     Results should lie between 4o - 175 % (Elongation %)
   - Investigation will be done cluring this week to test samples taken from the production after curing to find cause of the

fail and if it is due to lew temp. or due to short time during the curing process.

- Measure the conditions inside the chambers.
- Condition for material:

1. For semi conducter mat.

before drying		max. 1 ooo ppm (o.1 %)
after drying		max. 2oo ppm (o.o2%)
drying time	5 hours	
drying temp.	5o °C	
Recommending	6o °C and 4 hours	

2. For insulation mat.

before drying		max. 5 ooo ppm (o.5 %)
after drying		max. 2oo ppm (o.o2%)

Recommending drying the insulation by test:

GPE / 4oo	5o °C	5 hours
before drying		o.2 - o.3 %
after drying		o.o42 - o.o1o6 %

- ECE material suppliers never recommended the drying of the insulation material they only asked for the drying of the catalyst.

"ECE will ask the questin again to the material suppliers".

3. For catalyst:

Same temp. time as indicated above for insulation

- Record the result of drying test in laboratory in written form including all information:
  type of material, charge number,
  test operator and results of percentage moisture before and after drying.
- Starting from to date 6 collected cable defects will be analized and the cause for defect is define.

2. Drawing process:

- Drawing dies:
  The finishing of dies should be better
- Wires are toe dry:
  Mr. Hölzer will see the specification of the drawing oil to propose it is suitable or not (to increase the quality).

Date : o2.o6. 199o
Subject : Fourth meeting between Mr. Hölzer the UNIDO representative and ECE

Attendant : Mr. Hölzer
Mr. Iskander Fahmy
Mr. Ahmed Yosef
Mr. Samir Shouhdy

Coppies to : Mr. Hassan Helmy ECE President
Mr. M. A. Khalil ECE Factories Sector Director

Discusions were on stranding and insulation process of the compacted Conductors for MT-cables and hot-set-test

1. Stranding process:
   - ECE are using good M/CS.
   - Cold welding equipment are satisfactory.
   - Use only one die for copper and another die for aluminium.
   - Proportions of the die angles will be advesed later.
   - Use enamelling thinner insmall draps for the wire/die lubrication. It is preferable to have thin film of lubricating oil as the wires during the drawing process.
   - Care should be taken during the handling of the full spools between drawing m/c and stranding m/c. It is adisable to use special pallets.
   - ECE quality control system is explained to Mr. Hölzer and he handed a follow up sheet for the production and quality control system used at home.
   - Mr. Hölzer recommended to use the insentives system reduction in case of bad quality.

2. Medium tension insulation:
   - Insulation checking at sucessive internals of insolated cores, samples were taken from insolation m/c 6o/12o/9o - 2. Differences were masured and they change from one point to another and smetimes they are out of tolerances. Measuring sheets were handed to attendent. Those differences are due to unsynchronized inlet/outlet caterpillers are due

to change in screws (insolation and semi conductor) rotation speed or due to unfit extrusion toals.

- Mr. Hölzer recommended to use cleaning material of different nature than the expensine XLPE material. For example he is accustomed to use Union Carbide material DFDS o964 for both insolation and semi conductor extruders cleaning.
  A quantity of 1o kg can he used for 6o mm extruder
  15 kg 9o mm
  5o kg 12o/15o mm
  Mr. Hölzer will gine a written paper showing the cleaning process and temperature.
- Silicon oil spray should be use after cleaning and before montling m/c parts.
  In case silicon oil spray is not available, use silicon grease oil but in a very thin layer this is to reduse cleaning time.

3. Hot-set-test:
   - All samples with two layers succeded except one sample witch taken from m/c 9o/12o. For this m/c percentage catalyst should checked.
   - Eight samples with there layers extrusion failled, they have Union Carbide inner and outer semi conductors.
     One extra sample with same material was crosslinked after 48 hours in 9o°C water bassin (usual time for time layers cross linking in the same conditions is 6 hours for 8 mm thickness which crosseponds 48 hours in crosspolimery XLPE material in saturated steam at 9o°C.
   - Alsc two samples in 9o°C hot water after 54 (fifty four) hours never cross linked (failled).
     From all we have the ccnclusion:
     That is to say restudy your semi conductor material, curing time and percentage catalyst.

Date : 1o.o6. 199o
Subject : Fifth meeting between Mr. Hölzer the UNIDO representative and ECE

Attendant : Mr. Hölzer
Mr. Iskander Fahmy
Mr. Samir shouhdy

Coppies to : Mr. Hassan Helmy ECE President
Mr. M. A. Khalil ECE Factories Sectors Director

Discusions were on stranding dies, insolation process of MT-cables and hot-set-tests as follows:

1. Stranding carbide die:
   - Use only one die for one material.
   - The length of the conical drawing part should not be less than 6o %.
   - A proposal drawing for the die is handed by Mr. Hölzer
   - Shoulders of the should be rounded and surface should be mirror finished.
   - A recommended drawing angles are 18^{o} for copper and $22 - 25^{o}$ for aluminium
   - The cylinderical part length will be advised later.
   - Form for the production follow up is handed by Mr. Hölzer and he recommended to use for different medium tension production process.

2. Cleaning of XLPE extruders:
   - Mr. Hölzer handed the cleaning procedure
   - CABOT semi conductive material results for curing are not get finished.
   - Caring time for the italien XLPE should not be less than 48 hours for 12/2o KV (5.5 mm thickness).
   - Exact curing room temperature is not get available. When this temperature knouw we can exacthy fix the curing time.
   - Mr. Hölter recommended to use VDE o294/later edition for the medium tension conductor manufacturing.

- For better thickness adjustment during the insulation process, a longitudinal continuoes marks are recommended to specify the die direction of adjustment. Height should not be more than o.o8 mm.
- To inerease ECE medium tension cables quality follow VDE o273 for the core thickness.

3. Hints for insulation:
   - Cleanleness and order: This should be hospital cleaning.
   - Cleaning of the conductor before inlet to the extruder. Metal chips should be removed use round rotating plastic brash and compressed air wippers.
   - Use the transparent protecting tube between the inner semi conductor head and the XLPE with outer semi conductor head.
   - Removal of the extrudered material fine accumulated on the outer die during the extrusion process.
     Spray from time to time silicon oil on the exit of the last die.
     Also there should be no sharp edges on the exit of the last die (they should be rounded).
   - Mr. Hölzer recommended that the semi canductor granuals should be transmitted by as closed vacuum system from driers to the extruders.
     Mr. Hölzer recommended also to complete the available system.
   - Mr. Hölzer recommended to put the incoming material cases or sacs on pallets in a closed chamber.
   - Mr. Hölzer recommended to use brass rotating brushs instead of steel brushs which might hurt the screw/head pieces chromium plating and toels.
   - As discussed last meeting use silicaon oil spray on the screws c head pieces before mainting the m/c parts prior tc extrusion.
   - Mr. Hölzer recommended to use a safe spark tester for checking the insulated cores (after an air wipper) this equipment should have a detector to count the defect (contact SIKORA BREMEN W.-germany).
   - ECE semi conductive tape specification and quality should be change. Modifications to the available specifications will be handed by Mr. Hölzer.

Date : 16.o6. 199o
Subject : Sixth meeting between Mr. Hölzer the UNIDO representative and ECE

Attendant : Mr. Hölzer
Mr. Iskander Fhahmy
Mr. Samir Shouhdy
Mr. Ahmed Yosef

Coppies to : Mr. Hassan Helmy ECE President
Mr. M. A. Khalil ECE Factories Sectors Director

Discusion were on drawing dies, hot-set-test, insulation thickness, copper fail, screening process and laging up process of MT conductors as follows:

Drawing dies:

See the attached drawing of drawing dies
Mr. Hölzer recommended that:

$$\frac{I_3 + I_4}{I_2} \quad \frac{o.6o\ H}{(o.3 - o.33)\ d}$$

Balance of H = I_1

Hot-set-test:

From the test made on 12.o6. 199o and 13.o6. 199o samples are:
24o mm^2 12/2o KV three layers using cabot material 992/1 as semi conducting outer layer and as material on line 6o/12o/9o - 2

The results were as follow:

1. No curing occured in the curing chambers (test failed after curing)

2. Tests made in the labouratory should that curing occuring in some samples and not occuring in others it is observed that curing conditions occured at $55^{o}C$ for 48 and 72 hours.

Recommendations:

1. Increase the curing temperature to $9o^{o}C \pm 5^{o}C$
2. Check the %age catalyst addition on this line and others during the process.
3. After the excution of 1 and 2 recheck the cross linking.

Insulation thickness difference

From the measuring of thickness sheet dated 12.o6. 199o it is noticed that the inner semi conducting, XLPE insulation and the outer semi conducting thickness are changing.
(Measured on samples displaced 1oo mm in between manufacturel on line 6o/12o/9o - 2
it is noticed that:
the variation in the three layers as follows:

	min (mm)	max (mm)
inner semi conducting	o.695	1.129
insulation	5.292	6.448
outer semi conducting	o.534	o.985

Recommendations:

1. Check line synchronization
2. Check tools tolerances
3. Use the 1o times scalled lens
4. Check the thickness periodically (per eaeh length)

Copper foil:

VDE o273 states the max. value of resistivity of copper foil is o.o1786 $\Omega\ mm^2/m$ after processing.
ECE specification stated that min. purity of the tape should be 99.95 % and max. resistivity is o.o1724 $\Omega\ mm^2/m$.
Mr. Hölzer recommended eleminate the purity and keep the resistivity as it is because the final resistivity after processes be after lapping, laying up .... uptill the finished cable will increase more than the initiated value and it might reach the max. value stated in the VDE o273
To proof that the max. resistivity of the finished cable after processing is not more than o.o1786 $\Omega\ mm^2/m$ as per VDE o273, test will be made before and after processing for the measuring of the resistivity.

Screening Process:

Mr. Hölzer recommended to use polished guiding dies for the screening lines to prevent any damage to the cable components during screening (ex. scraches, hammering the cable surface due to unbalance tension of the used one copper tape).
Also extrimities of the cable on the take - up drum should protected against any chocks or damage.
Difference between cable diameter and used dies should not exceed two mm to prevent the cable damage due to vibration of the cable inside the die.

Laging up:

Max. lay length is 18 D as per VDE o273
In practice use (16 - 18) D D(is the diameter after laging up - (the cable).
- Use polished assembly dies.
- Adjust the guiding roller of the catarpiller and along the line to be suitable to the cable diameter.

- Some metal chips are abserued on the line due to the rough guides.

All parts touching the cable should be cleaned and polished, its vary eften to clean minimum once per shift.

Minimizing of scrap:

Calculate the actual value of ECE medium tension % age.

Date : 24.o6. 199o
Subject : Seventh meeting between Mr. Hölzer the UNIDO representative and ECE

Attendant : Mr. Hölzer
Mr. Iskander Fahmy
Mr. Samir Shouhdy
Mr. Admed Yosef

Coppies to : Mr. Hassan Helmy ECE President
Mr. M. A. Khalil ECE Factories Sectors Director

Discusion were on sheathing process, partial dischargetest, high voltage test and scrap % age for MT-cables as follows:

1. Over all sheathing process:
   - ECE have agood 15o mm line.
     It aduisable to add another pay-off and another take-up to sharpen the line effeciency specially when change the cable length under sheathing and off course spare pay-off and take-up will save the changing time.
   - Mr. Hölzer advised to use the correct reel size from the barrel diameter point view (ratio of the barrel diameter and the cable diameters).
     And also to use suitable reel size for the cable length under sheathing.
     It was observed that:
       a) reels with small barrel diameter are used
       b) reels are full of cable and same lay of cable are heigher than the flange so the total weight of the reel is supported on the cable and not supported on the wooden flange.
   - Over all diameter monotoring equipment feeding back to the extruder main motor is not used.
   - Cable identification by embossing or by printing on the cable sheath such as type, cross section, voltage rating, produser and consamer names, cable length and year of

production should be printed on all the cables sheaths.
- It is observed that the wheel printing the cable langth is not working.
- Use the proposed quality test certificate from one process to the following process.

2. Partial discharge test:
   - Use all of the screen range for calibrating the equipment for the cable length and size under measurement.
   - Use fixed connectors for the cable screen for both cable ends.
   - The sheilding room floor should be covered by epoxy.
   - Rectify the sheilding room internal electrical connectors.
   - Reffering to the PD tests made during 1. - 19.o6. 199o the average percentage of cables having PD over 2o PC is 18 - 48 % and the international percentage is 1 (one) % max.
   - It is understood that ECE locate the places of high PD in the 18 - 48 % cable and cut the cables at mentioned places and retest them and use the good cable but this 18 - 48 % are too high and the whole medium tension processes should be reviewed.

3. High voltage test:
   - The new WBM equipment are goodones.
   - Testing cells places should be sufficiently secured for human safing.
   - Make the diemension and construction tests on samples from each finished length.
   - Also do the resistance test using mentioned samples.
   - Thru cables defects were analysed and the result showed That they are due to contamination in the insulation. Samples are reserved in the laboratory.

4. Scrap percentage:
   International level of scrap % for different meterials and processing steps are as follows:

drawing process	Al	1.o - 1.5 %
	Cu	o.6 - 1.o %

stranding process	Al	o.8 - 1.o %
	Cu	o.5 - o.8 %
Insulation process		2.o - 4.o %
Screening process		o.5 %
laying process		o.5 - 2.o %
filling process		1.o %
armouring process		1.o %
sheathing process		1.o %
test field		o.3 %

Recommended standards

1. International electrotechnical comission (IEC)

IEC	38	IEC standard voltage
IEC	6o	High-voltage test techniques
IEC	183	Guide to the selection of high-voltage cables
IEC	228	Conductors of insulation cables
IEC	229	Test on cable oversheath which have a special protective function and are applied extrusion
IEC	23o	Impulse tests on cables and their accessories
IEC	27o	Partial discharge measurements
IEC	287	Calculation of the continuous current rating of cables (1oo % load factor)
IEC	332	Tests on electric cables under fire conditions
IEC	5o2	Extruded solid dielectric insulated power cables for rated voltages from 1KV up to 3o KV
IEC	54o	Test methods for insulation and sheaths of electric cables and cords (Elastomeric and thermoplastic compounds)

2. VDE-Standards

VDE	o2o7	Insulation and sheathing compounds for cables and lines
VDE	o2o9	Tests for insulation and sheathing material
VDE	o295	Conductors for cables and lines
VDE	o271	Thermoplastic insulated cables
VDE	o272	Cables with insulation of XLPE 1 KV
VDE	o273	Cables with insulation of XLPE 6/1o, 12/2o, 18/3o KV
VDE	o427	Tests of cables and lines
VDE	o3o3	Tests of semiconductiv tape

3. British standards (BS)

BS	5467	Armoured cables with thermosetting insulation for electricity supply.
BS	5468	Cross linked polyethylene compounds
BS	5469	6746 6791 1442 4o66

4. ASTM-Standards (American society for testing and materials)

D	149	Tests for dielectric breakdown voltage and dieletric strength of electrical insulating materials at commercial power frequencies
D	257	Tests for DC-Resistance or conductance of insulating materials
D	1248	Specification for polyethylene plastic molding and extrusion materials
ASTM		IPCEA S-66-524 ; AEIC CS 5
D	1928 C ; D 1505 ; D 638 ; D 756 ; D 2765 A ; D 1531 ; D 1238	
		150 / D 159073

5. ICEA/NEMA-Standards (Insulated cable endineers association/ national electrical manufacturers association)

WC	7 - 1982	Cross-linked-thermosetting-polyethylene-insulated wire and cable for the transmission and distribution of electrical energy
WC	3 - 1980	Transmission and distribution of electrical energy

6. Deutsche Industrie Norm (DIN)

DIN 53854 ; 53855 ; 53857 ; 53482 ; 53495 ; 54305

All for tests of semiconductiv tape.

Recommended equipment

1. Plastic-corder 330 and rheotron for tests of purity of XLPE - compounds
   Supplier: Comp. BRABENDER, D - 4100 Duisburg 1, Germany
2. Microscope with measurement reading and profil-projector (V - 12)
   Supplier: Comp. NIKON, Chiyoda-Ku, Tokyo 100, Japan
3. Recommended standards according to annex 2

Annex 3 : - Senior counterpart staff
- List of people met .
- Carrying - out of training programme and some test - result

Senior counterpart staff

1. Eng. Hassan Hilmy Said Chairman	ELECTRO CABLE EGYPT (ECE)
2. Eng. Iskander Fahmy Technical Manager and Member of Board of Directors	ECE
3. Eng. M. A. Khalil Director of Factories Sectors and Member of Board	ECE
4. Eng. Ragaey Awad Allah Boulas Research and Laboraty Manager	ECE
5. Eng. Samir S. Shehate Research Engineer	ECE
6. Eng. Ahmed Hassan Youssef Production Engineer	ECE
7. Chemist Fouad Khalil Manager of Power Cables Sector	ECE

List of people met

1. Mr. Sabry Programme Officer	United Nations Development Programme in the Arab Republic of Egypt
2. Mr. Dr. Mazhar First Under-Secretary	Ministry of Industry in the Arab Republic of Egypt
3. Eng. Brain Roberts Sales Director	Babcock Wire Equipment Limited England - Lancashire
4. Eng.Gary M. Jarvis Commissioning Engineer	Babcock Wire Equipment Limited England - Lancashire
5. Mr. D. J. M. Gargadennec Product Manager	Comp. Carl Freudenberg Nonwovens Division Viledon Germany - Weinheim
6. Mr. Ahmed M. Osman General Manager	Alosmany Modern Building & Trade Egypt - Giza
7. Dipl.-Ing. J. Huppertz Anlagenprojektierung	MWB Prüfsysteme GMBH Germany - Bamberg

Cairo, d. 8.o6.9o

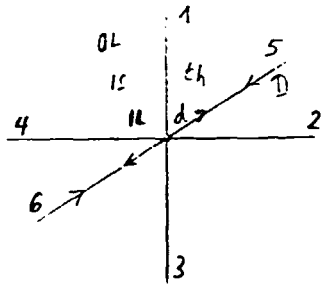
Procedure of cleaning with cleaning material

1. Type	:	DFDM o964 or LD 1925 22	UNION CARBIDE BP	
2. Quantity	:	For one times Extruder	6o	1o kg
			9o	15 kg
			12o	5o kg
			15o	5o kg

3. Action :
- Drive extruder empty (< 5 rpm)
- Put cleaning material in
- Temperature slows down to 1o5 ... 11o° C and observation the compound pressure (Limit)
- Drive extruder empty (< 5 rpm)
- Dismantling the extruder head
- Pulling out the screw
- Waiting for cooling obout 5 to 1o min.
- Removing the cleaning material after shrinkage
- After cleaning use siliconoilspray
- Put in the screw and assembling the head

Insulation - thickness - test (one example) acc. to VDE

Date : 1o/6/9o
Type : NA2X 24o mm^2 12/2o KV drum-no. 22
Machine : 12o/6o/9o No. 2
Results :



3 Layers:

1. Inner Layer Il o.7 ± o.1 (o.6 ... o.8)
2. Insulation IS 5.5 ± o.65 (4.85 ... 6.15)
3. Outer Layer OL o.8 ± o.1 (o.7 ... o.9)

1 - 3. Thickness th 7.o ± o.85 (6.15 ... 7.85)

D = 2 th + d d = 18.3

	1	2	3	4	5	6	Ø	min.	max.
IL	o.695	1.o12	o.964	o.826	o.92o	o.873	o.882	o.695	1.o12
IS	6.o84	6.444	6.6o3	6.o43	5.935	6.133	6.2o7	5.935	6.6o3
OL	o.534	o.742	o.8o8	o.577	o.593	o.57o	o.637	o.534	o.8o8
th	7.313	8.193	8.375	7.446	7.448	7.576	7.726	7.313	8.375

D 1 - 3 = 33.988

D 2 - 4 = 33.944

D 5 - 6 = 33.324

max. diff. = o.664

acc. to VDE o273 $\leq$ o.5

Hot-set-test (one example) acc. to IEC

Type : NA2X 24o mm^2 12/2o KV drum-no.22
Material : CABOT 892/1 (semiconductiv)
POLIDAN PE/G 2
Machine : 12o/6o/9o No. 2

Results :

Sample-No.	Date	Curing time	Hot-set	Remark
1	12/6/9o	48 h	2o6 %	failed
2	13/6/9o	72 h	o %	failed
3	13/6/9o	72 h	367 %	failed
4	16/6/9o	72 h	253 %	failed
5	16/6/9o	48 h	68,9 %	o.k.
6	19/6/9o	48 h	179,6 %	failed

Result should be between 4o ... 175 %.

Partial Discharge (PD) - Test (one example)

According to VDE o472 max. 5 pC
According to IEC 54o max.2o pC

No	date	tested numbers of drums	not accepted drums	PD-accepted pC		PD not accepted pC		% not accepted
				min.-max.		min.-max.		
1	2.6.9o	17	3	14	2o	3o	>1oo	17.65
2	3.6.9o	17	1	6	18	>1oo		5.88
3	4.6.9o	16	3	5	18	36	-	18.75
4	5.6.9o	33	7	8	2o	25	-	21.21
5	6.6.9o	26	3	5	2o	25	-	11.54
1 - 5		1o9	17	5	2o	25	>1oo	15.59
6	9.6.9o	35	1o	12	2o	6o	-	28.57
7	1o.6.9o	27	6	4	2o	7o	-	22.22
8	11.6.9o	11	2	12	2o	9o	-	18.18
9	12.6.9o	24	2	3	2o	7o	-	8.33
1o	13.6.9o	3o	6	3	2o	45	-	2o.oo
6 -1o		127	26	3	2o	45	>1oo	2o.47
11	16.6.9o	23	2	3	2o	>1oo		8.69
12	17.6.9o	11	2	1o	2o	25	-	18.18
13	18.6.9o	22	4	3	2o	7o	-	18.18
14	19.6.9o	11	5	1o	2o	25	-	45.45
11-14		67	13	3	2o	25	1oo	19.4
1-14		3o3	56	3	2o	25	1oo	18.48

International level is $\leq$1 % not accepted.