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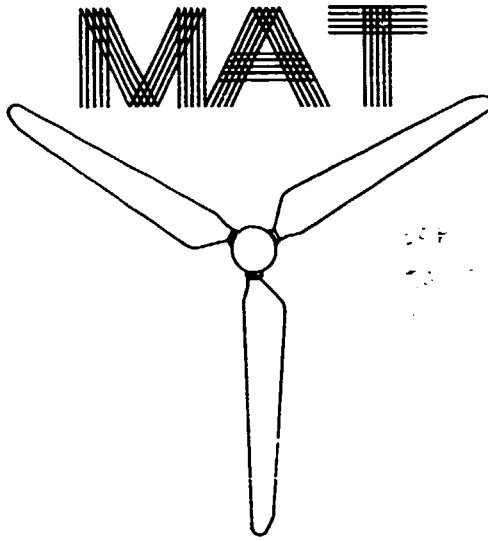

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CONTRACT NO. 89/58

between

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

(UNIDO)

and

MAT AIRFOIL A/S OF DENMARK

UNIDO Project No. DP/EGY/88/001
Activity Code: J13318

TRANSFER OF TECHNOLOGY

FOR THE DESIGN AND MANUFACTURE OF WIND TURBINE BLADES

in

THE ARAB REPUBLIC OF EGYPT

Final Report

June 19th, 1990.

Based on work made by MAT AIRFOIL A/S.

Report made by: Project Team Leader Niels Mathiesen.

Executing Officer: D. Gardellin, Director
General Services Division
Department of Administration
UNIDO
P.O.Box 300, A-1400 Vienna
AUSTRIA

62

TABLE OF CONTENTS

	Page:
Section 1.00 Aim of the Report and general conclusions	1
Paragraph 1.01 Synopsis	1
Section 2.00 Equipment and production materials	1
Section 3.00 Documentation	1
Section 4.00 Training of Egyptian personnel	2
Paragraph 4.01 General informations	2
Paragraph 4.02 Engineers	2
Paragraph 4.03 Technicians	3
Section 5.00 Shipment	3
Paragraph 5.01 Shipment of equipment and production materials	3
Paragraph 5.02 Shipment of documentation	3
Section 6.00 Project Area Services	3
Paragraph 6.01 Project Team Leader	3
Paragraph 6.02 Project Assistant	4
Section 7.00 Workshop layout	4
Paragraph 7.01 Workshop for winding of spars	4
Paragraph 7.02 Workshop for hand layup of GRP-laminates	5
Section 8.00 Manufacture of the proto type set of blades in the Project Area	5
Paragraph 8.01 Winding of spars	5
Paragraph 8.02 Hand layup	5
Section 9.00 Briefing and debriefing of the Resident Representative of the UNDP in Cairo	5
Paragraph 9.01 Briefing	5
Paragraph 9.02 Debriefing	6
Section 10.00 Conclusions	6

LIST OF ANNEXES

Annex A-2.00 : Equipment
Annex A-2.04 : Packing list
Annex A-3.00 : Documentation

Annex B-1 : Training Program no. 1 for technicians
Annex B-2 : Training Program no. 2 for technicians
Annex B-3 : Training Program for engineers

Annex C-1 : Time table for the total project.
Annex C-2 : Time table for the work carried out in the Project Area.

1.00 AIM OF THE REPORT AND GENERAL CONCLUSIONS

1.01 Synopsis

This Draft Final Report describes the execution of all work carried out in connection with UNIDO Contract No. 89/58 between UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION and MAT AIRFOIL A/S as detailed in the time table for the total project, a copy of which is attached hereto as Annex C-1.

The aim of the contract is the transfer of technology to Suez Shipyard in Egypt so that the Suez Shipyard can manufacture wind turbine blades suitable for wind turbines in the 100 kW ranges.

To achieve the transfer of technology MAT AIRFOIL A/S has successfully supplied all documentation, assisted, guided and trained Suez Shipyard personnel as well as supplied production equipment and certain materials, and provided expertise at the Suez Shipyard for establishment of production facilities and pilot manufacture of the proto type set of blades.

2.00 EQUIPMENT AMD PRODUCTION MATERIALS

All moulds, templets, machines, utilitytools, production materials etc. as detailed in the list of equipment and in the packing list, copies of which is attached hereto as Annex A-2.00 and Annex A-2.04 is produced and delivered to the Suez Shipyard.

3.00 DOCUMENTATION

All documentation such as design, calculations, tests, drawings, specifications, work instructions, quality assurance system and service handbook as detailed in the list of documentation, a copy of which is attached hereto as Annex A-3.00, is delivered in the english language to Suez Shipyard and in 3 copies one of which is of master quality.

4.00 TRAINING OF EGYPTIAN PERSONNEL

4.01 General informations

The Egyptian personnel, a total of nine (9) persons, arrived at Copenhagen Airport on Monday September 4th, 1989.

The names of the Egyptian personnel is:

Senior engineer Mohamed E. Khalil
Engineer Ibrahim Abdel Gawad Eldisouki
Engineer Ismail Ibrahim Eldisouki
Technician Abdel Bari Mahmoud Eldidi
Technician Mohamed Abdel Kadr Hagrass
Technician Ahmed Aly Mohamed
Technician Fouad Mohamed Ahmed
Technician Abdel Magid Housin Abdelmagid
Technician Yehia Seideldin Ismail

Senior Engineer Khalil staid at MAT AIRFOIL A/S to Sunday September 24th, 1989 and the rest of the personnel staid at MAT AIRFOIL A/S to October 4th, 1989.

The training of the Egyptian personnel took place 5 days a week, monday to fridag, from 8 am in the morning to 3 pm in the afternoon. From 3 pm to 4 pm in the afternoon all were together for an evaluation meeting, where the training program of the day were evaluated and any questions debated. Evaluation forms for each training day and each person were daily filled in, and by the end of the whole training, a certificate was drawn up for each person.

Certificates and training programs are attached hereto as Annex B-1, B-2 and B-3.

The Egyptian personnel were all in sympathy with the subject and the training, which was successfully accomplished.

4.02 Engineers

The two engineers Mr. Ibrahim Eldisouki and Mr. Ismail Eldisouki went through the detailed training program, a copy of which together with certificates are attached hereto as Annex B-3.

The engineers studied the delivered documentation with great attention. They followed the production of the blades in the factory and were very interested in the subject and quick learning. During the training period, they got a temporary copy of most of the documentation in english.

4.03 Technicians

The two groups of technicians went through the detailed training programs, copies of which together with certificates are attached hereto as Annex B-1 and Annex B-2.

The technicians made great attentions to the subject and got a very well knowledge of how to make windmill blades of reinforced glassfibre polyester resin.

5.00 SHIPMENT

5.01 Shipment of equipment and production materials

All equipment, production materials and hand tools for manufacturer of the proto type set of blades in Egypt, were packed in a 40 ft. container in week no. 40/89.

Shipment from Ringsted was executed October 6th, 1989, and arrived in Alexandria - Egypt October 27th, 1989. The container arrived to Suez Shipyard on Sunday November 19th, 1989.

The content of the container was checked and controlled in accordance with the packing and equipment lists, and everything was found in accordance with the lists and accepted by the Suez Shipyard.

5.02 Shipment of documentation

At the PTL's arrival to the Project Area November 12th, 1989 all documentation was delivered in the english language. The documentation in 3 copies one of which is of master quality was evaluated and accepted by the Suez Shipyard engineers.

The delivery of all documentation to Suez Shipyard is confirmed on the receipt dated November 15th, 1989, a copy of which was attached to the 4th Interim Progress Report.

6.00 PROJECT AREA SERVICES

6.01 Project Team Leader (PTL)

The Project Team Leader (PTL), Mr. Niels Mathiesen, arrived to Cairo November 8th, 1989 in the evening and staid in Cairo to November 12th, 1989 for briefing of UNDP and to be paid the equivalent of United States Dollars five thousand (US$ 5,000) in Egyptian Pounds to cover local expenses in accordance with contract paragraph 4.04 b.

On Sunday November 12th, 1989 the PTL was picked up by the Suez Shipyard Engineer, Mr. Ismail, and went to Suez Shipyard.

The services of the PTL in the Project Area - Suez Shipyard - was carried out in accordance with the time outline as detailed in the time table, a copy of which is attached hereto as Annex C-2.

November 29th, 1989 the PTL went to UNDP in Cairo for debriefing and returned to Denmark November 30th, 1989.

6.02 Project Assistant (PA)

The Project Assistant (PA), Mr. Knud Nielsen, arrived to Suez Shipyard November 22nd, 1989 and carried out the services in the Project Area in accordance with the time outline as detailed in the time table, a copy of which is attached hereto as Annex C-2.

The PA returned to Denmark December 12th, 1989.

7.00 WORKSHOP LAYOUT

7.01 Workshop for winding of spars

In the Project Area a workshop layout for winding of spars was planned and agreed with the engineers from Suez Shipyard. Foundations for the winding machine and the hydraulic trigger was prepared and carried out. Electrical installations was planned and prepared before the erection of the machinery.

The Suez Shipyard personnel was supervised in making supports for resin barrels and winding mandrels. Production tables for manufacture of nozzles and plugs as well was made and erected, and fire protection equipment was installed.

Production line for future mass production was discussed and agreed.

After the container arrived to the Shipyard, the machinery was levelled and erected on the foundations and electrical connected.

The Suez Shipyard personnel and the PTL went through the machinery and materials specification and know-how for maintenance of production equipment.

Test run of the machinery was carried out.

7.02 Workshop for hand layup of GRP-laminates

Moulds for hand layup of shells, cover plates and flap doors was installed in an existing GRP-workshop. Minor replacement of the lighting system in the workshop was carried out.

Production line for future mass production was discussed and agreed.

8.00 MANUFACTURE OF THE PROTO TYPE SET OF BLADES IN THE PROJECT AREA

8.01 Winding of spars

The manufacture of the spars was started under guidance and assistance of the PTL Wednesday November 22nd, 1989.

Quality control was carried out by measurements of the spar laminate thickness and calculation of the glass content of the spar laminate.

The production plan is detailed in the time table, a copy of which is attached hereto as Annex C-2.

8.02 Hand layup

The hand layup of shells, cover plates and flap doors as well as the gluing, assembling, finishing and balancing of the blades was successfully carried out under guidance and assistance of the Project Assistant in accordance with the time outline as detailed in the time table, a copy of which is attached hereto as Annex C-2.

9.00 BRIEFING AND DEBRIEFING OF THE RESIDENT REPRESENTATIVE OF THE UNDP IN CAIRO

9.01 Briefing

At the Project Team Leader's arrival to Cairo, the Resident Representative of UNDP, Mr. Sabry, was informed of the assignment and plans for the performance of the work in the Project Area.

The Resident Representative of UNDP, Mr. Sabry, was kept currently informed by telephone calls from Suez Shipyard of the progress of the assignment and plans for the performance of the work in the Project Area in the period of the PTL's stay in the Project Area.

9.02 Debriefing

November 29th, 1989 the PTL returned to Cairo for debriefing. The Resident Representative of UNDP, Mr. Sabry, was informed about the work carried out in the Project Area in accordance with the time outline as detailed in the time table, a copy of which is attached hereto as Annex C-2.

10.00 CONCLUSIONS

Minor delays during the project period have not affected the project as a hole.

The transfer of tech..ology - supply of all documentation, assistance, guidance and training of Egyptian personnel as well as supply of production equipment and certain materials for the manufacture in Egypt - is successfully completed.

Provision of expertise at the Suez Shipyard for establishment of production facilities and pilot manufacture of the proto type set of blades is successfully completed.

The Suez Shipyard personnel is in our opinion well trained and educated and will in the future be able to manufacture the MAT Wind Turbine Blades at a high level of quality.

Ringsted, June 19th. 1990.

MAT AIRFOIL A/S

f. Niels Mathiesen - Project Team Leader

Manager.

2.00 EQUIPMENT.

PARAGRAPH	DESCRIPTION	NOS
2.01	**MOULDS:**	
	Flange inside, model	1 no
	Flange outside, model	1 no
	Nozzle inside and outside mould	1 set
	Plug inside nozzle	1 no
	Winding mandrel	1 no
	Mould for coverplate	1 no
	Moulds for blade (two part mould)	1 set
	Flap door mould	1 no
2.02	**TEMPLETS:**	
	Nozzle, fibreglass	1 set
	Plug inside, fibreglass	1 set
	Coverplate, Divinycell	1 set
	Coverplate, Firet	1 set
	Coverplate, fibreglass	1 set
	Blade, Divinycell	1 set
	Blade, fibreglass	1 set
2.03	**MACHINES - UTILITYTOOLS:**	
	Winding machine	1 no.
	Trigger, hydraulic, for wounded spar	1 no.
	Blade wagon	1 no.
	Tip angle tools (tip and root)	2 nos.
	Scale for tip	1 no.
	Scale for root	1 no.

PACKINGLIST.

MATERIALS FOR 3 PROTOTYPES 9,2 M BLADES:

Polyester resin type Alpolit UPS 335		3 Fats
Polyester resin type Alpolit UP 334		2 Fats
Peroxide type Butanox M 50		4x5 kg
Peroxide type Butanox LPT		3x5 kg
Kobolt 1% ig		4 kg
Inhibitor NLC 10		2 kg
No stick		1 kg
Gelcoat type Civic 2101 H		4 Pails
Chopped strand mat 450 g	128 kg	4 Rolls
Chopped strand mat 300 g	38 kg	2 Rolls
Undirectional rowing 150 / 780 g	70 kg	Rolls
Undirectional rowing 210 / 278 g	415 kg	Rolls
Woven rowing 50 / 50, 600 g	28 kg	1 Roll
Acetone		1 Fat
Acetone valve		1 No
Polyester resin valve		2 Nos
PVC foam		5 Sets
PVC foam H 40, 6 mm		3 Plates
Firet 2 mm		1 Sqm
Glue type Ferro		2 Pails
Plastorite 00	258 kg	6 Sacks
Sliva Band 140 mm		5 Rolls
PVC tube, 3"		2 m
Wood 40 x 40 mm		2 m
Stainless steel 2 mm		5 nos
Stainless steel 50 x 20 x 2 mm		10 Nos
Polyester foil		1 Roll
Flange OLB - 8501		5 Nos
Flange OLB - 8502		5 Nos
Bushings for flanges		120 Nos
Foam rubber plugs		120 Nos
Plastic plug K 10		5 Nos
Plastic plug in balancing tube		10 Nos
Plastic plug in root end		10 Nos
Screw 4,2 x 16 mm SS		100 Nos
Screw 2,9 x 9,5 mm SS		100 Nos
Screw 4 x 6 mm SS		100 Nos
Screw 4 x 8 mm SS		100 Nos
Tubular rivets, 3,2 mm		100 Nos
Tubular rivets, 4,8 mm		100 Nos
Rubber list for flapdoor		10 m
Sikaflex 221		12 Tupes
Primer		1 l
Silicone		2 Tupes
Hinge , right		5 Nos
Hinge , left		5 Nos
Lock plate		5 Nos
Release mechanism		5 Nos

Cover plate for release mechanism	5 Nos
Cover plate for balancing room	5 Nos
Name plate	5 Nos
Tape type Tedlar	1 Roll
Tape type Alu.	1 Roll
Parachute	5 Nos
Universal joint, swirvel, bolt, washer locknut	5 Nos
Stop furnishing for wire	10 Nos
5 mm rapide connector link and chain	5 Nos
Wire incl. welding of furnishing	5 Nos
Round lock and tubular rivet	10 Nos
Leather protection	5 Nos
Schackle	8 Nos
Parashutebrackets	5 Nos
Tubular rivets	20 Nos
Locking plate for flapdoor	5 Nos
Screws	20 Nos
Gelcoat for mould repair	1 kg
Tubes for locking device	5 Nos
Paint for flanges	5 kg

TOOLS FOR ERECTION AND PRODUCTION:

Lambskin rollers large	15 Nos
Lambskin rollers small	15 Nos
Lambskin rollers small, short shaft	5 Nos
Brushes , long shaft 25 mm	5 Nos
Brushes , long shaft 35 mm	5 Nos
Brushes , long shaft 50 mm	5 Nos
Brushes 25 mm	10 Nos
Brushes 50 mm	10 Nos
Brushes 100 mm	10 Nos
Nylon rollers 14 x 100	10 Nos
Nylon rollers 10 x 80	10 Nos
Alu rollers 22 x 140	10 Nos
Peroxid bottles	5 Nos
Polish paper	1 Roll
Rubber gloves	50 Pairs
Working gloves	2 Pairs
Dust masks	1 Box
Vapor masks	2 Nos
Grinding paper	1 Roll
Water grinding paper no. 400	50 Nos
Water grinding paper no. 800	30 Nos
Water grinding paper no. 1200	20 Nos
Grinding dishes	3 Nos
Boatrubbing	3 Bottles
Boat polish	3 Bottles
Wax	1 Bottle
Silicon spray	1 No

Cotton waste	1 Sack
Silan	1 kg
Pole checking device	1 No
El suckets	20 Nos
Cables	50 m
Level	1 No
Drilling machine large	1 No
Drilling machine small	1 No
Toolbox with handtools	1 Box
Expansionbolts for the winding machine	100 Nos
Bolts and screws	1 Box
Extension cables	50 m
Bending spring	1 No
Hand milling tool for K 10	1 No
Crepe tape 50 mm	10 Rolls
Crepe tape 25 mm	10 Rolls
Cello tape 25 mm	10 Rolls
Rubber hammer	1 No
G.T.	4 kg
Pails 10 litres	10 Nos
Pails 1 Litre	10 Nos
Pails 0,5 litre	10 Nos
Wooden wedge	1 Box
Wooden veneer for lining of the mould	1 Box
Mixing devices	1 Box
Filling knife 100 mm	3 Nos
Filling knife 50 mm	3 Nos
Filling knife standard	3 Nos
Tubular rivet tong	1 No
Talurit tong	1 No
Bolt for connection of flanges	5 Nos
Cleaning cream	1 l
Hole saw ø 105 mm	1 No
Hole saw ø 76 mm	1 No
Hole saw center	1 No
Drill for erection of parachutebolt	1 No
Lifting strap	1 No
Countersink	1 No
Load for adjustment of release mechanism	1 No

3.00 DOCUMENTATION

3.01 DESIGN - CALCULATIONS - TESTS:

Risoe design basis for 3 - blade stall - regulated windmills.	1 set
Design and construction calculations	1 set
Static tests and approvals by Risoe.	1 set
Technical specifications	1 set
Powercurves by Risoe.	1 set
Air brake release calculations	1 set

3.02 DRAWINGS:

Flange inside	1 no.
Flange outside	1 no.
Plug inside nozzle	1 no.
Wounded spar	1 no.
Assembly of spar	1 no.
Cover plate	1 no.
Blade, laminate specifications	1 set
Assembly parts	1 no.
Air - brake	1 no.
Assembly	1 set
Winding machine - diagrams	1 set

3.03 SPECIFICATIONS:

Castings
Sandblasting / galvanizing
Painting
Polyester
Gelcoat / topcoat
Fibreglass
Rowing
Divinycell
Firet
Cure - temp. and time
Glue

3.04 **WORKINGINSTRUCTIONS:**

Nozzle inside mould
Plug inside nozzle
Winding of spar
Mounting of spar
Coverplate
Blade
Finish
Weight control and adjustment

3.05 **QUALITY CONTROL:**

Qualityhandbook
Qualitycontrol raw materials
Qualitycontrol halffabricate
Processcontrol
Qualitycontrol, finished blades
Productioncontrolcard

3.06 **SERVICE:**

Service handbook
Service checkplan
Maintenance plan

MAT AIRFOIL A/S
EGYPT - PROJECT

TRAINING PROGRAM NO. 1:
TRAINING PROGRAM FOR 4 EGYPTIAN TECHNICIANS AT MAT AIRFOIL A/S IN RINGSTED-DENMARK, FROM SEPTEMBER 4, 1989 TO OCTOBER 3, 1989 (WEEK NO. 36, 37, 38 AND 39).

PRODUCTION OF THE BLADE SHELLS:

Make ready the mould.
Cutting of fibreglass.
Cutting of PVC foam.
Apply gelcoat to the mould.
Laying up the laminate.
Curing.
Make ready the shells for gluing (sanding).
Make ready the spar for gluing (sanding).
Joint by gluing the spar and the shells.
Release from mould.
Finish of edges and joints.

PRODUCTION OF THE COVER PLATE:

Make ready the mould.
Cutting of fibreglass.
Cutting of PVC foam.
Laying up the laminate.
Joint by gluing.
Curing.
Release from mould.
Finish.

PRODUCTION OF THE FLAP DOOR:

Make ready the mould.
Cutting of fibreglass.
Cutting of PVC foam.
Laying up the laminate.
Curing.
Release from mould.
Finish.

ERECTION OF THE BLADE:

Joint the cover plate by gluing.
Erection of the flap door.
Balancing of the blade.
Marking the tip chord at flange.
Painting of flange.
Jointing between flange and shells.
Erection of air brake release mechanism.
Adjusting of release mechanism.
Erection of air brake parachute.
Erection of cover plates for release mechanism and balancing room.
Erection of PVC plugs in root and tip end.
Erection of name plate.

Total: 160 hours.

Technician Abdel Bari Mahmoud Eldidi

Technician Abdel Magid Housin Abdelmagid

Technician Fouad Mhamed Ahmed

Technician Yehia Seideldin Ismail

MAT AIRFOIL A/S
EGYPT - PROJECT

TRAINING PROGRAM NO. 2:
TRAINING PROGRAM FOR 2 EGYPTIAN TECHNICIANS AT MAT AIRFOIL A/S IN RINGSTED-DENMARK, FROM SEPTEMBER 4, 1989 TO OCTOBER 3, 1989 (WEEK NO. 36, 37, 38 AND 39).

PRODUCTION OF CONNECTING-PIECE (NOZZLE) ON FLANGE:

Make ready the mould.
Make ready the steel flange.
Cutting of fibreglass.
Laying up the nozzle laminate.
Curing.
Release from mould.
Drilling of bolt holes.

PRODUCTION OF PLUG INSIDE NOZZLE:

Make ready the mould.
Cutting of fibreglass.
Laying up the plug laminate.
Curing.
Release from mould.
Drilling of holes for PVC plugs.

PRODUCTION OF THE WOUNDED SPAR:

Make ready the mandrel.
Erection of the nozzle on the mandrel.
Erection of the mandrel in the winding machine.
Make ready the winding machine.
Winding of the spar.
Curing.
Release of the spar from the mandrel.

ERECTION OF THE SPAR:

Make ready the outer steel flange.
Make ready the root end of the spar for gluing (sanding).
Gluing the outer steel flange to the spar.
Erection of bushings in bolt holes.
Make ready the plug for gluing (sanding).
Gluing the plug in the root end of the spar.

PRODUCTION OF THE HANG FOR THE PARACHUTE:

Production of leather protection for stainless steel chain.
Erection of leather protection on chain.
Assembling of hang (universal joint, shackle, chain with protection, rapide connector link and parachute).

Total: 160 hours.

Technician Mohamed Abdel Kadr Hagrass

Technician Ahmed Aly Mohamed

MAT AIRFOIL A/S
EGYPT - PROJECT

TRAINING PROGRAM FOR EGYPTIAN PRODUCTION ENGINEER STAYING AT MAT'S FACTORY FROM SEPTEMBER 4TH, 1989 TO OCTOBER 3TH, 1989. (WEEK NO. 36, 37, 38 AND 39).

MOULDS, TEMPLETS, MACHINES AND TOOLS.

1	Knowledge of moulds and templets.....	10 hours
2.	Knowledge of winding machine and hydraulic trigger. Diagrams, service and maintenance.....	20 hours
3.	Knowledge of utility tools.....	10 hours
4.	Inspection of moulds, templets, machines and tools for delivery to Egypt.....	10 hours

MATERIALS AND SUPPLIES.

5.	Knowledge of design, calculations and tets.....	30 hours
6.	Knowledge of drawings.....	30 hours
7.	Knowledge of materials specifications.....	15 hours
8	Knowledge of working instructions.....	10 hours
9.	Knowledge of quality control system.....	20 hours
10.	Knowledge of service.....	5 hours
	Total	160 hours

Engineer Ibrahim Abdel Gawad Eldisouki

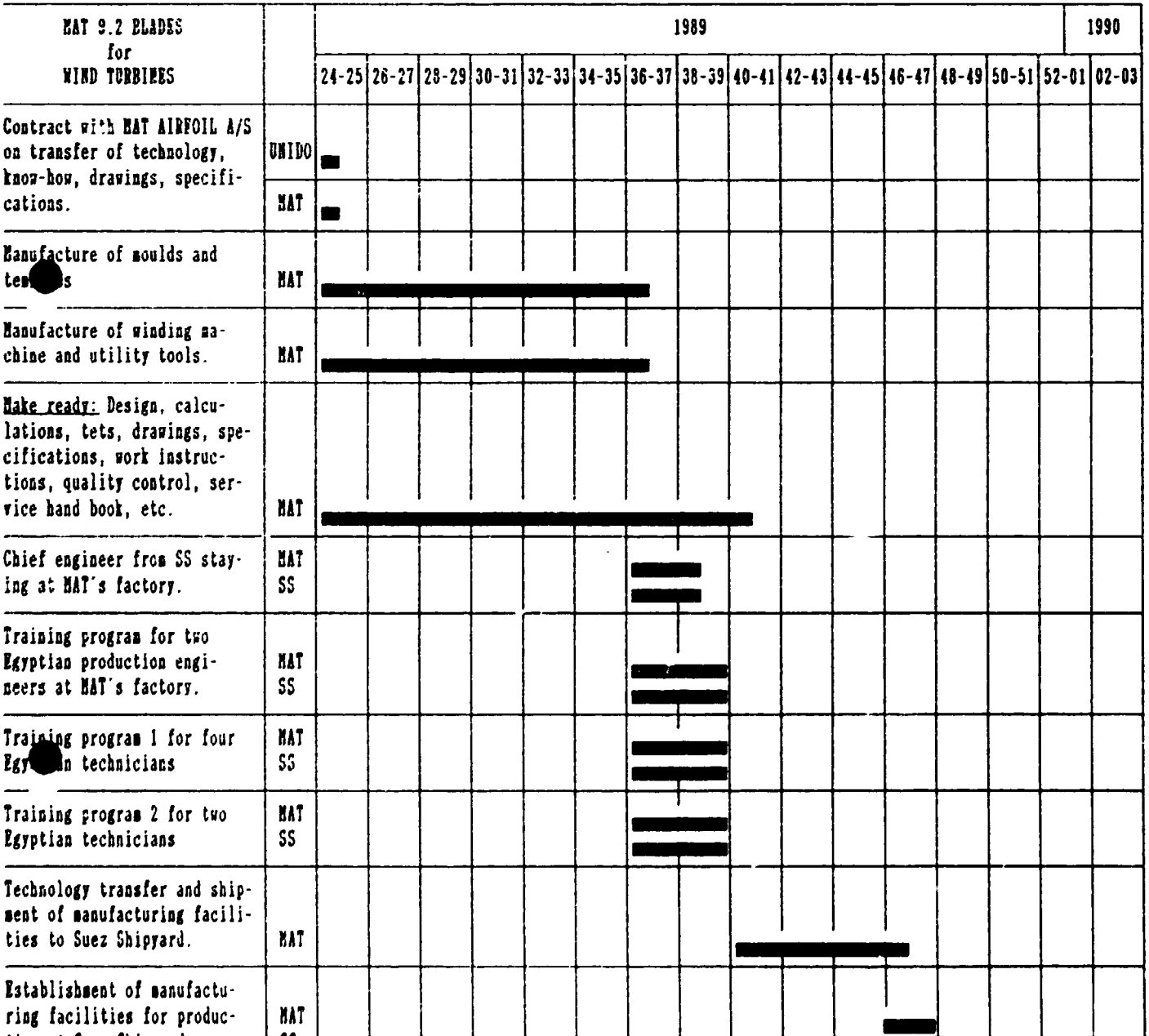
Engineer Ismael Ibrahim Eldisouki

ANNEX C-1.

EGYPT PROJECT, UNIDO CONTRACT NO. 89/58.

TECHNOLOGY PACKAGE FOR THE DESIGN AND MANUFACTURE FOR BLADES FOR WIND TURBINES.

TIME TABLE FOR THE TOTAL PROJECT.



TIME TABLE FOR THE WORK CARRIED OUT IN THE PROJECT AREA

ANNEX C-2

SUBJECT	November 1989																					December 1989														
	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	01	02	03	04	05	06	07	08	09	10	11	12	13	14