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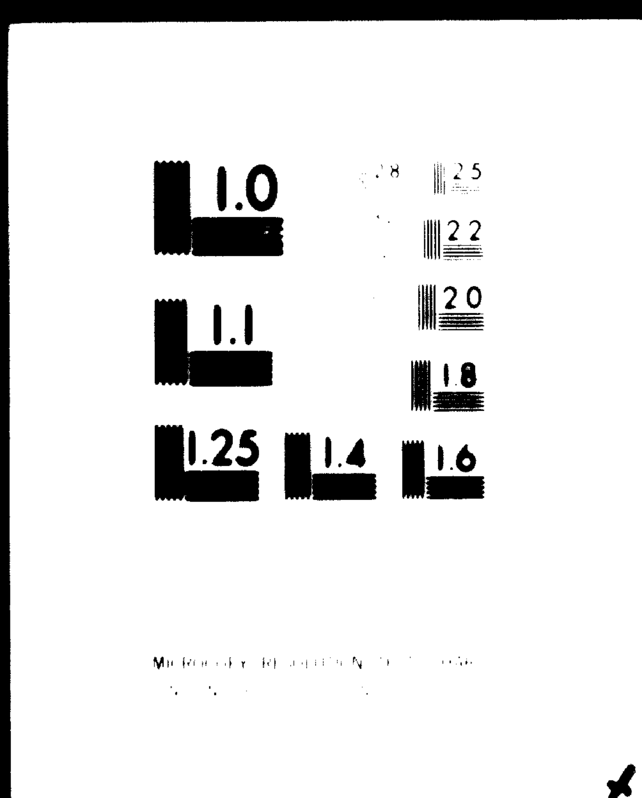

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Report 1

REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"

This report has been written by

Grels Berg, AB Energikonsult, Sweden,
and has been finished on January 31, 1973.

Report 2

PRINCIPAL DESIGN OF BIOLOGICAL TREATMENT OF WASTE WATERS FROM "FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"

This report has been written by

Jan Rennerfelt, Scandiaconsult International AB, Sweden,
and has been finished on June 26, 1973.

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23/7/73

REPORT 1

REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELLULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"

ABSTRACT

In order to meet the increased demand of steam and electric power, the industrial power station in Banja Luka has to be enlarged. We propose that the enlargement shall comprise a new boiler, a new back pressure turbine, a new 20 kV distribution system and a new 110 kV electric connecting line to the grid.

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INTRODUCTION

The industrial complex in Banja Luka consists of factories for the production of dissolving pulp on Ca basis, rayon, high wet modulus fibers, cellophan, paper, electrolysic products of NaCl. New factories are under construction for the production of light concrete and polyester. Plans are made for a increase of the pulp mill capacity with about 100 %.

When we originally received this contract from UNIDO in Aug 1971, the main purpose of the job was to make certain plans for helping Banja Luka with the following items

- Conversion to Mg-basis
- Increase of the production by about 100 %

After starting the job we found out at our first visit in Banja Luka 25-29 Oct.1971 that Banja Luka had no interest of our services as they were proposed, because Banja Luka already had ordered the complete job from KMW.

With your approval the extention of our job was limited to concern only the power station, and that part was separated from KMW's contract.

We then started the calculations for the power station and according to Banja Luka's wishes the pulp mill should be converted in such a way that it should be possible to produce either dissolving pulp 371 t/day or paper grade pulp 477 t/day. Based on these premises we made a preliminary report of 2 June 1972 which is now without interest and the preliminary report will therefore be omitted in this connection.

In a later stage the conversion to Mg was abandoned and the plans for the pulp mill should now concern only an increased production of dissolving pulp 371 t/day on Ca-basis. This final draft report concerns the enlargement of the steam power station according to these premises.

After a new visit in Banja Luka 7-9 June 1972 we made the report of 6 July 1972 in which we observed the view points of Banja Luka. In this report we proposed the enlargement of the power station to consist of a boiler with capacity 180 t steam/h fired with pulverized coal, fuel oil, bark and sulphite liquor and of a back pressure turbine of 27 MW. The capital investment for this enlargement was calculated to 109 MDin for the boiler plant, 35 MDin for the turbine plant or a total of 144 MDin.

In a report of 9 Nov. 1972 we have made recommendations and plans for a new 20 kV switchgear, a new transmission line 110 kV and a 20 kV distribution system for the new factories. In the same report we have also made plans for reconstruction of the existing 6 kV distribution system.

The reports were discussed in Banja Luka 27-28 Nov. 1972 and we then got new instructions. In order to reduce the capital investment, the new boiler should be made only for coal and oil. The existing boilers cannot burn all bark and sulphite liquor from the enlarged mill but Banja Luka says that they will possibly use the bark and the liquor as raw materials for same industrial processes.

Banja Luka also wanted to reduce the sizes of the new boiler and new turbine. Until Banja Luka could make decisions they wanted that in the further planning two alternative sizes should be regarded for the new boiler and new turbine. After discussions the following sizes were accepted as base for the further planning.

Alternative		1	2	3
New Boiler K5	t/h	140	180	180
New Turbine T4	"	-	12	23

Based on these data we made calculations concerning the revised design of boiler and turbine of 22 Dec. 1972 and the specifications for boiler and turbine. The specifications are then made for two alternative sizes. We are aware of the fact that asking tenders for alternative sizes is a mischief that should be avoided as it gives the bidder unnecessary work and perhaps prevents same bidder of making a tender.

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REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"

1 PRODUCTION

The actual production in the dissolving pulp mill on Ca-basis is 200 t/day. After the pulp mill has been enlarged and the new factories for production of light concrete and polyester have been finished, the production will be

Product	Production	Production time h/year
Dissolving pulp (90 % dry solids)	371 t/day	8 000
Electrolytic products	8 000 t NaOH/year	8 000
Paper	5 000 t/year	7 000
Rayon	50 t/day	8 000
High wet modulus fibers	25 "	8 000
Cellophane	10 "	8 000
Polyester	?	8 000
Light concrete	?	8 000

2 EXISTING STEAM POWER STATION

BOILER PLANT

Steam data

- Design pressure 86 bar
- Steam temperature 515/525 °C
- Feed water temperature 143 °C

The plant consists of the following four boilers which are connected to each other on the high-pressure side.

Boiler K1, delivered from Cail-Denain-Steinmüller and taken into operation in year 1959. Main fuel is pulverized coal. Auxiliary fuels are sulphite liquor 15 t/h fired in a Lurgi oven and bark 10 m^3/h fired on a 5 m^2 sloping grate.

The steam generating capacity is

Nominal load	50 t/h
Max. continuous load	64 "
Peak load during 2 hours	70 "

Boiler K2, same data as for boiler K1

Boiler K3, delivered from Mitsubishi and taken into operation in year 1969. Pulverized coal is the main fuel. Auxiliary fuel is sulphite liquor 2 x 15 t/h fired in two Loddby muffles.

The steam generating capacity is the same as for boiler K1.

Boiler K4, same data as for boiler K3, with the exception that this boiler has no Loddby muffles.

TURBINE PLANT

Steam data

- Admission steam pressure 70 bar
- Admission steam temperature 515 °C

The plant consists of the following 3 turbines.

Turbine T1. This back pressure turbine is delivered from Erste Brünner and taken into operation in year 1959.

		Actual condition	After reconstruction
Max Steam flow	t/h	72	70
Back pressure	bar	4.5	7.5
Bleeding at 7.5 bar (uncontrolled)	t/h	15	-
Max generator power	MW	10	7.0

Turbine T2. This double extraction-condensing turbine is delivered from Mitsuhishi and taken into operation in year 1969.

Admission steam flow	118 t/h
Uncontrolled bleeding	
- Max flow	18 t/h
- Pressure at full load	16 bar
Controlled extraction	
- Max flow	103.5 t/h
- Pressure, controlled	4.2 bar
Max generator power	16 MW

Turbine T3, same data as for turbine T2

FEED WATER TREATMENT PLANT

The feed water treatment plant consists of a demineralization plant in 6 lines with a total continuous capacity of 280 t/h.

FEED WATER PUMPING STATION

The feed water pumping station consists of the following pumps.

- Electric pumps 3 x 75 t/h	225 t/h
3 x 125 "	375 "
Total electric pumps	600 t/h
- Steam turbine driven pump 1 x 200 t/h	200 t/h
Total capacity	800 t/h

ELECTRIC HIGH TENSION SYSTEM

The industrial combinate Banja Luka is connected to the grig with a 35 kV line with transmission capacity of about 10 MW. The generator tension for the existing turbines is 6 kV, which is also the tension for the power plant switchboard and the distribution tension to the factories.

3 CONSUMPTION OF HEAT AND STEAM

The calculations for the future consumption of heat and steam appear from the report of 6 June 1972 which is here attached as Appendix 1.

The results are

Mean consumption		Heat Gcal/h	Steam t/h
Summer time			
Steam 13 bar		14.1	21
" 7.5 bar		26.6	42
" 4.5 bar incl steam for feed water heating		109.5	225
	Total	150.2	288
Winter time			
Steam 13 bar		14.1	21
" 7.5 bar		26.6	42
" 4.5 bar incl steam for feed water heating		130.0	265
	Total	170.7	328
Peak consumption in winter		181.0	347

4 CONSUMPTION OF ELECTRIC POWER

The calculations for the future consumption of power appear from the report of 6 June 1972, which is here attached as Appendix 1.

The results are

Energy consumption	312 GWh/year
Power peak load	47 MW

5 PREMISES FOR THE DESIGN OF THE POWER STATION ENLARGEMENT

The following principles shall be regarded.

- The enlargement shall comprise one new boiler K5 and one turbine T4. The existing boilers and turbines shall be kept in operation.

- The new boiler and the new turbine shall be placed in connection to the existing power station.

- The steam data for the new units shall be taken to the same as for the existing units, design pressure 86 bar, steam temperature 515°C and feed water temperature 143°C. The new units shall on the high pressure side be connected to the existing high pressure header system in order to make possible parallel run between the new and existing units.

- The main fuel in the new boiler shall be pulverized coal. Fuel oil shall be used as auxiliary fuel. The possibility of burning bark or sulphite liquor in the new boiler shall not be regarded although the calculations show that the existing boilers cannot burn all available bark and sulphite liquor in the future.

- The total boiler capacity shall in winter time be sufficient for the maximum demand, when all five boilers are in operation. In summer time shall the boiler capacity be sufficient also when one of the existing boilers No 1-4 is out of operation. With this design it must be observed that outage of boilers in winter time may cause limitation of production because of steam shortage.

- The new turbine T4 shall be designed without regard of turbine reserve.

- The existing turbine T1 shall be preserved as a back pressure turbine with back pressure 4.5 bar.

Calculation for the design of the new boiler and new turbine appears from the report of 6 July 1972 which is attached as Appendix 1 and from the report of 22 Dec 1972 which is attached as Appendix 4.

6 DESIGN OF THE ENLARGEMENT OF THE POWER STATION

The following alternatives shall be regarded for the further planning of the power station enlargement.

Alternative		1	2	3
Boiler K5				
Max. steam generating capacity	t/h	140	180	180
Turbine T4				
Max. generator power	MW	-	12	23

Concerning the new turbine the following points must be observed.

- In alternative 1 cannot a new turbine be installed because of lack of steam capacity. When all the existing turbines are in operation cannot the electric max. peak demand be covered.

- In alternative 2 shall the new turbine be installed in an extention of the existing turbine house.

- In alternative 3 shall the existing turbine T1 be removed and in the free place shall the new turbine be installed.

- The steam balances shows that the new turbine shall be made as a back pressure turbine without condensing part.

- In all alternatives is the turbine capacity insufficient when one turbine is out of operation.

Design of boiler K5

Alternative		1	2 and 3
Design pressure	bar	86	86
Steam temperature	°C	515	515
Feed water temperature	°C	143	143
Steam generating capacity			
Nominal load	t/h	100	140
Max. continuous load	"	120	160
Peak load during 2 hours	"	140	180
Main fuel		Pulverized coal 100 % load	
Auxiliary fuel		Fuel oil 50 % load	

The specification for the boiler is attached as Appendix 6. The specification concerns a turn-key boiler plant with building, instrumentation, electric equipment and pipes.

Design of turbine T4

Alternative		2	3
Admission steam			
- Pressure	bar	70	70
- Temperature	°C	515	515
- Flow	t/h	80	150
Back pressure	bar	4.5	4.5
Bleeding 13 bar	max.t/h	30	30
Bleeding 7.5 bar	max. "	-	15
Max. generator load	MW	12	23
Generator tension	kV	10	10

The specification for the turbine is attached as Appendix 7. The specification concerns a turn-key plant with building, instrumentation, electric equipment and pipes.

Feed water treatment plant

The existing demineralization plant with 6 lines with a total continuous capacity of 280 t/h is sufficient for the enlarged plant.

Feed water pumps

The existing feed water pumps with a capacity of 660 t/h for electric driven pumps (6) and 200 t/h for one steam turbine driven pump is sufficient for the enlarged plant.

WARM WATER SUPPLY IN THE ENLARGED PULP MILL

The pulp mill needs warm water of 40°C and 70°C. The heat balances for the factory which is base for the design of the new boiler is made on the assumption that warm water is produced not using primary steam but secondary heat sources. A proposition for the hot water supply appears from Appendix 2.

ELECTRIC POWER SUPPLY

The calculations show that the existing transmission time 35 kV with a capacity of about 10 MW is insufficient for the future needs. In order to ensure the supply of electric power in the future also when outage at the turbines is regarded, the transmission capacity should at least be 15-25 MW depending on the alternative chosen for the power station enlargement. A new transmission line for 110 kV is needed.

The generator and distribution tension in the existing power station is 6 kV. This system cannot with reasonable costs be extended for the enlargement of the factories.

The new turbine generator tension is proposed to be 10 kV, and a 20 kV distribution system is needed for the enlargement of the factories.

The propositions for the enlargement of the electric equipment appears from Appendix 3.

CONCLUSIONS AND RECOMMENDATIONS

After enlargement of the pulp mill, and when the new factories now under construction are finished, the need for heat and power for the industrial combinate in Banja Luka will be as follows:

Max. heat demand for the factories	181 Gcal/h
Corresponding demand on steam	347 t/h
Max. steam flow to the condensing parts of the turbines 2 x 27 t/h	54 "
Total max steam demand	401 t/h

Max. electric power demand 47 MW

The max. total continuous steam generating capacity in the existing power plant when all four boilers are in operation is 4 x 64 t/h 256 t/h

The max. total power generating capacity for the existing three turbines is 42 MW

In order to secure the future demand of heat and power for the industrial combinate, the following measures must be taken.

- Installation of a new boiler and a new back pressure turbine. The following alternatives will be regarded.

Alternative		1	2	3
Boiler capacity	t/h	140	180	180
Turbine capacity	kW	-	12	23

  The choice of alternative will depend on how Banja Luka valuates the security in heat and power supply and of Banja Luka's financial possibilities.

- Installation of a new electric transmission line 110 kV.
- Installation of a new 20 kV switchgear in the power station and of a new 20 kV distribution system for the factories.

Stockholm, January 31, 1973

AB ENERGIKONSULT

Grels Berg

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, VIENNA

CONTRACT 71/50

Report 1 — **REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"**

Appendix 1 — Report of 6 july 1972 concerning the enlargement of the steam power station.
(Kalküle betr. den Ausbau der Kraftzentrale in Zellstoffabrik Banja Luka)
Beilagen 1-9

AB ENERGIKONSULT

FABRIKA CELULOZE I VISKOZE, BANJA LUKA
Kalküle beträffend den Ausbau der
Kraftzentrale in Zellstoffabrik Banja Luka

Stockholm, den 6.7.1972
AB ENERGIKONSULT
Greis Berg

AB ENERGIKONSULT

Fabrika celuloze i viskoze, Banja Luka

Kalküle betreffend den Ausbau der Kraftzentrale in Zellstoffabrik Banja Luka

INHALTSVERZEICHNIS

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6.7.72

Fabrika celuloze i viskoze, Banja Luka

Kalküle betreffend den Ausbau der Kraftzentrale in Zellstoffabrik Banja Luka

1. Produktion

Die gegenwärtige Zellstoffproduktion ist 200 tZ[x)]/24 h Viskosezellstoff auf Ca-Base. Die Zellstoffabrik ist an einer Kraftzentrale angeschlossen, die auch Fabriken für Papier, Elektrolyse, Zellwolle, HWM und Zellophan mit Dampf und elektrischer Kraft versorgt.

Man hat den Absicht die Zellstoffabrik zu erweitern - für eine grössere Produktion von Viskozezellstoff auf Ca-Base. An der Kraftzentrale sollen ausserdem neue Fabriken für Polyester und Gasbeton angeschlossen werden.

Nach dem Ausbau wird die Produktionskapazität betragen:

Gebleichter Zellstoff	371 tZ/24 h -	8 000 h/Jahr
Elektrolyse	8 000 t NaOH/Jahr	8 000 "
Papier	5 000 t/Jahr	7 000 "
Zellwolle	50 t/24 h	8 000 "
High Wet Modulus (HWM)	25 "	8 000 "
Zellophan	10 "	8 000 "
Polyester	? "	8 000 "
Gasbeton	? "	8 000 "

x) tZ = t Zellstoff mit 90 % Trockengehalt

2. Gegenwärtige Kraftzentrale

Die gegenwärtige Kraftzentrale umfasst folgende Kessel und Turbinen. Der Konzessionsdruck der Kessel ist 87 atü, Dampftemperatur 515/525°C und Speisewassertemperatur 143°C. Admissionsdampfdaten für die Turbinen ist Druck 71 atü und Temperatur 515°C.

Kessel K1, von Cail-Denain-Steinmüller gebaut, und im Jahre 1959 in Betrieb genommen. Kohlenstaub ist der Hauptbrennstoff, dazu können noch 14 t Sulfitlauge im Lurgiofen und Rinde am Schrägrost 5 m^2 verfeuert werden.

Die Dampfleistung ist

Nominaldauerbelastung	50 t/h
Maximaldauerbelastung	64 t/h
Spitzenbelastung während 2 Stunden	70 t/h

Kessel K2. Dieselben Daten als für K1.

Kessel K3, von Mitsubishi-Kisha Seizo geliefert und im Jahre 1969 in Betrieb genommen. Kohlenstaub ist der Hauptbrennstoff, dazu kann Sulfitlauge in zwei Loddby-Muffeln 2 x 7,5 = 15 t Lauge/h verfeuert werden.

Die Dampfleistung ist

Nominaldauerbelastung	50 t/h
Maximaldauerbelastung	64 t/h
Spitzenbelastung während 2 Stunden	70 t/h

Kessel K4. Dieselben Daten als für K3, doch hat der Kessel K4 keine Loddby-Muffeln, und ist nur für Kohlenstaubfeuerung ausgerüstet.

Turbine T1 von Erste Brünner geliefert und im Jahre 1959 in Betrieb genommen. Die Turbine ist eine reine Gegendruckturbine

Wirtschaftliche Dampfdurchflussmenge	59,3 t/h
Maximale "	72,0 "
Generatorleistung bei max. "	7,8 MW

Turbine T2, von Mitsubishi geliefert und im Jahre 1969 im Betrieb genommen. Die Turbine ist eine Kondensationsturbine, die mit einer ungeregelten und einer geregelten Entnahme für Fabrikationsdampf vorgesehen ist.

Admissionsdampfflussmenge	118 t/h
Ungeregelte Entnahme	
- Max. Menge	18 t/h
- Druck bei Vollast	15,2 atü
Geregelte Entnahme	
- Max. Menge	103,5 t/h
- Druck	3,2 atü
Max. Generatorleistung	16 MW

Turbine T3, dieselben Daten als für T2.

3. Wärme- und Dampfverbrauch

Der Wärme- und Dampfverbrauch nach dem Ausbau ist in Beilage 1 berechnet. Die Berechnungen basieren sich für die Zellstoffabrik auf Angaben von KMW und für die übrigen Fabriken auf Angaben von Banja Luka.

Die wichtigsten Resultaten der Berechnungen sind

Verbrauch im Mittel	Wärme Gcal/h	Dampf t/h
Sommerzeit:		
Dampf 12 atü	14,1	21
Dampf 6,5 atü	26,6	42
Dampf 3,5 atü einschl. Speisewasserwärmung	109,5	225
Summe	150,2	288
Winterzeit:		
Dampf 12 atü	14,1	21
Dampf 6,5 atü	26,6	42
Dampf 3,5 atü einschl. Speisewasserwärmung	130,0	265
Summe	170,7	328
Geschätzter max. Verbrauch im Winter	181,0	347

4. Elektrischer Kraftverbrauch

Der Elkraftverbrauch nach dem Ausbau ist in Beilage 2 berechnet. Die wichtigsten Resultate der Berechnungen sind

Jährlicher Energieverbrauch	312 GWh/Jahr
Maximaler Leistungsbedarf	47 MW

5. Die Auslegung des Ausbaus der Kraftzentrale

Beim Ausbau sollen die folgenden Prinzipen berücksichtigt werden:

Der Ausbau soll einen Kessel K5 und eine Turbine T4 umfassen.

Der neue Kessel K5 und die neue Turbine T5 sollen im Anschluss an der vorhandenen Kraftzentrale gebaut werden.

Für den neuen Kessel soll derselbe Genehmigungsdruck 87 atü und Dampftemperatur 515/525°C als für die vorhandenen Kessel gewählt werden, so dass es möglich wird, der neue Kessel mit den vorhandenen auf der Hochdruckseite zu verbinden.

Die Grösse des neuen Kessels K5 soll so ausgelegt werden, dass im Winterzeit einer der vorhandenen Kessel K1-K4 für Reparatur ausser Betrieb genommen werden kann, ohne Dampfmangel zu verursachen. Dabei soll auch die Produktion von elektrischer Kraft berücksichtigt werden.

Der neue Kessel soll für Verbrennung von Kohlenstaub, Sulfitlauge und Rinde ausgelegt werden.

Die Verbrennungskapazität für Lauge- und Rindefeuerung soll so ausgelegt werden, dass der Kessel K5 allein die totale Menge von Lauge und Rinde verfeuern kann. Dabei wird der Kesselbetrieb einfach, da Lauge und Rinde bei normalem Betrieb nur in einem Kessel verfeuert werden.

Die Turbine T4 soll für die maximale Dampfleistung des Kessels K5 ausgelegt werden, so dass der Kessel und die Turbine als ein Block getrieben werden können, ohne Verbindungen auf der Hochdruckseite mit den vorhandenen Kesseln.

Die Auslegung gemäss diesen Prinzipen geht von den Beilagen 4-8 hervor, und gibt folgendes Resultat:

Kessel K5

Genehmigungsdruck	87 atü
Dampftemperatur	515/525 °C
Speisewassertemperatur	143 °C
Maximale Dampferzeugung	180 t/h

Turbine T4

Admissionsdampf

Druck	71 atü
Temperatur	515 °C
Wirtschaftliche Dampfmenge	150 t/h
Max. Dampfmenge	180/195 t/h
Entnahme für 13 atü Dampf, max.	50 t/h
Gegendruck	4 atü
Max. Generatorleistung	27 MW
Generatorspannung	~10 kV

Die Feuerungskapazität des Kessels K5 für Sulfitlauge soll folgenderweise ausgelegt werden

Lauge vor Verbrennung

Trockengehalt	55 % TS
Trockensubstanz	1,38 t TS/tZ
Unterer Heizwert	2 000 kcal/kg Lauge
Laugemenge im Mittel	
bei Produktion 371 tZ/24 h	2,5 t Lauge/tZ
	38,7 t Lauge/h
Max. Laugemenge wenn Schwankungen	
in Laugezufuhr beachtet wird	48 t Lauge/h

Die Feuerungskapazität des Kessels K5 für Rinde soll folgenderweise ausgelegt werden

Trockengehalt	65 % TS
Trockensubstanz im Mittel	123 t TS/24 h
Volumengewicht	155 kg/m^3
Unterer Heizwert	430 Mcal/m^3
Volumenmenge im Mittel	1 230 m^3/24 h
	51 m^3/h
Max. Volumenmenge wenn Schwankungen	
in Zufuhr beachtet wird	80 m^3/h

Verbrennungskapazität des Kessels

Feuerung von Lauge und Rinde	Normal	Maximal
Wärmezufuhr an den Feuerraum	Gcal/h	Gcal/h
Lauge 38,7 bzw. 48 t/h	77,4	96,0
Rinde 51 bzw. 80 m^3/h	21,9	34,4
Kohlenstaub 12,8 bzw 3,9 t/h	44,7	13,6
Summe bei 85 % Wirkungsgrad		
$\frac{180 \text{ t/h} \cdot 0{,}678 \text{ Gcal/t}}{0{,}85}$	144,0	144,0

Die Verbrennungskapazität für Kohlenstaub soll so ausgelegt werden, dass bei Ausfall der Lauge und Rinde, volle Dampferzeugung nur mit Kohlenstaub allein erreicht werden kann. Die Kapazität der Kohlenstaubfeuerung muss denn 41 t Kohlenstaub/h betragen.

Der Kessel K5 wird mit eigenen Speisepumpen ausgerüstet, zwei elektrisch getriebene und eine mit Dampfturbine getrieben, alle drei für Vollast ausgelegt.

Der Kessel wird mit eigenen Dampfreduktionsstationen ausgerüstet, die den Dampf zu den Netzen 12 und 3,5 atü speisen können, bei Ausfall der Turbine T4.

Für die Dampfverteilung zu der Zellstoffabrik müssen folgende Massnahmen gemacht werden.

Dampf 12 atü

Eine neue Leitung 150 m, 250 mm Ø, für 35 t/h ausgelegt, muss zwischen der Kraftzentrale und der Kocherei installiert werden.

Dampf 3,5 atü

Eindampfanlage. Die vorhandene Leitung 300 mm Ø ist ausreichend.

Kocherei. Die vorhandene Leitung 400 mm Ø ist ausreichend.

Bleicherei. Die vorhandene Leitung 400 mm Ø ist ausreichend.

Trockenanlage. Die vorhandene Leitung 350 mm Ø für 6,5 atü, wird für 3,5 atü umgeschaltet und ist ausreichend.

Die vorhandene Speisewasserbereitungsanlage mit Vollentsalzung in 6 Linien für eine totale Bruttokapazität von 280 t/h ist ausreichend und darf nicht erweitert werden.

Die neue Turbine T4 kann wegen der Kurzschlussleistungen nicht an die vorhandene 6 kV-Schaltanlage angeschlossen werden. Wir setzen voraus, dass die Turbine T4 über einen Transformator an eine neue 20 kV-Schaltanlage angeschlossen wird, und dass neue Kraftverbraucher mit 20 kV gespeist wird.

6. Erzeugung von elektrischer Kraft

Die folgenden ökonomischen Kalküle werden zeigen, dass die folgenden Prinzipe richtig für die eigene Krafterzeugung sind.

Gegendruckkraft soll so viel wie möglich erzeugt werden.

Kondensationskraft soll im solchen Grade erzeugt werden, dass Einkauf von Kraft vermieden wird.

Erzeugung von Kondensationskraft für Verkauf ist nicht berechtigt.

Wenn diese Prinzipe gefolgt werden, soll nach Ausbau der Kraftzentrale die eigene Krafterzeugung folgendermassen gemacht werden.

Maximale Erzeugung von Gegendruckkraft	304 GWh/Jahr
Erzeugung von Kondensationskraft	16 "
	320 GWh/Jahr
Überschuss von Gegendruckkraft, die verkauft werden muss	8 "
Differenz = eigener Verbrauch	312 GWh/Jahr

7. Ökonomische Berechnungen

Die ökonomischen Berechnungen basieren sich auf die folgenden Angaben, die wir in Banja Luka bekommen haben.

Preis von Steinkohle im Kraftwerk	99,7 Din/t
Unterer Heizwert der Kohle	3 500 kcal/kg
Einkaufspreis für Kraft	0,17 Din/kWh
Verkaufspreis für Kraft	0,10 "

Wir berechnen zuerst die Brennstoffkosten für Erzeugung von Gegendruck und Kondensationskraft

Gegendruckkraft

$$\frac{950 \text{ kcal/kWh} \cdot 99{,}7 \text{ Din/t}}{0{,}85 \cdot 3\,500 \text{ kcal/kg}} = \underline{\underline{0{,}032 \text{ Din/kWh}}}$$

Kondensationskraft

$$\frac{2\,400 \text{ kcal/kWh} \cdot 99{,}7 \text{ Din/t}}{0{,}85 \cdot 3\,500 \text{ kcal/kg}} = \underline{\underline{0{,}081 \text{ Din/kWh}}}$$

Wenn man diese Brennstoffkosten mit den Einkaufs- und Verkaufspreisen für Kraft vergleicht, kann man einsehen, dass die Erzeugung von Gegendruckkraft immer berechtigt ist. Die Erzeugung von Kondensationskraft ist auch dann berechtigt, wenn die Kondensationskraft die eingekaufte Kraft ersetzt. Erzeugung von Kondensationskraft für Verkauf ist kaum berechtigt, wenn auch die anderen beweglichen Kosten berücksichtigt werden.

In Beilage 9 ist die Kapitalinvestierung für Ausbau der Kraftzentrale berechnet, wie folgt

Kesselanlage 180 t Dampf/h		109 MDin
Turbinenanlage 27 MW		35 "
	Summe	144 MDin

Die Dampfkesselanlage KS muss angeschafft werden, um die planierte Produktion zu erreichen.

Wenn die Turbine T4 nicht angeschafft wird, kann Gegendruckkraft mit den vorhandenen Turbinen T1, T2 und T3 ungefähr 280 GWh/Jahr erzeugt werden. Der Kraftmangel, der dann eingekauft werden muss, wird folgendes betragen

Leistung	18 MW
Energie	32 GWh/Jahr

Wenn die Turbine T4 angeschafft wird, wird die Fabrik selbstversorgend mit Kraft, und man erhält einen kleinen Überschuss von Gegendruckkraft, die verkauft werden muss. Erzeugung von Kondensationskraft für Verkauf, wird in den folgenden Berechnungen nicht berücksichtigt.

Wir berechnen jetzt die Räntabilität für die Anschaffung der Turbine T4.

Einkommen

Mehrerzeugung von Kraft die eingekaufte Kraft ersetzt

32 GWh/Jahr · 0,17 Din/kWh	=	5,44 MDin/Jahr

Überschuss von Gegendruckkraft zum Verkauf

8 GWh/Jahr · 0,10 Din/kWh	=	0,80 "
Summe		6,24 MDin/Jahr

Ausgaben

Brennstoff für Mehrerzeugung von Gegendruckkraft	
24 GWh/Jahr · 0,032 Din/kWh	0,77 MDin/Jahr
Brennstoff für Erzeugung von Kondensationskraft	
16 GWh/Jahr · 0,081 Din/kWh	1,30 "
Unterhaltungskosten für T4	
2,5 %/Jahr · 35 MDin	0,88 "
Betriebspersonalkosten für T4	
5 Mann · 20 000 Din/MannJahr	0,10 "
Summe	3,05 MDin/Jahr

Das Nettoeinkommen beträgt

$$6{,}24 - 3{,}05 = \underline{\underline{3{,}19\ \text{MDin/Jahr}}}$$

und ist in Prozent von Kapitalinvestierung

$$\frac{3{,}19\ \text{MDin/Jahr}}{35\ \text{MDin}} = \underline{\underline{9{,}1\ \%/\text{Jahr}}}$$

In diesen Berechnungen sind Kosten für Reservekraft, die eingekauft werden muss, bei Ausfall der Turbine T4 nicht berücksichtigt.

8. Zusammenfassung

Die gegenwärtige Zellstoffproduktion von 200 tZ/24 h Viskosezellstoff auf Ca-Base soll auf 371 tZ/24 h erhöht werden. An der Kraftzentrale ist ausser der Zellstoffabrik auch Fabriken für Papier, Elektrolyse, Zellwolle, HWM, und Zellophan angeschlossen. Im Bau sind Fabriken für Polyester und Gasbeton, die auch an der Kraftzentrale angeschlossen werden sollen.

Um die erhöhte Zellstoffproduktion und die übrigen neuen Fabriken mit Dampf zu versorgen, muss ein neuer Dampfkessel K5 mit einer Kapazität von 180 t Dampf/h angeschafft werden. Dieser Kessel soll mit Kohlenstaub, Sulfitlauge und Rinde gefeuert werden.

Die Kapitalinvestierung für diese Kesselanlage beträgt

109 MDin

Für diesen Kessel kann eine Gegendruckentnahmeturbine T4, 27 MW, angeschafft werden. Diese Turbine, zusammen mit den vorhandenen Turbinen, macht das Kombinat selbstversorgend mit Kraft.

Die Kapitalinvestierung für diese Turbinenanlage beträgt

35 MDin

Der Gewinn in Betriebkosten beträgt	3,2 MDin/Jahr
und sind in Prozent von der Kapitalinvestierung	9,1 %/Jahr

Diese Räntabilität ist mit der Voraussetzung berechnet, dass die erzeugte Kondensationskraft für Verkauf keinen Gewinn gibt. Wir bedenken jedoch, dass die Möglichkeit zur Erhöhung der Kondensationskrafterzeugung zum Verkauf, die extra 100 GWh/Jahr beträgt, und nicht in den Kalkülen berücksichtigt ist, doch ein beträchtlicher Wert hat. Wenn das berücksichtigt wird, wird auch die Räntabilität für die Anschaffung der Turbine T4 erhöht.

Stockholm, den 6.7.1972.

AB ENERGIKONSULT

Grels Berg

Grels Berg

Beilagen:

1. Wärme- und Dampfverbrauch
2. Elektrische Kraftbilanz
3. Erzeugung von Kraft
4. Auslegung von Gegendruckturbine, Zeichnung 101-500505-4001
5. Dampf- und Kraftmengen, nur Gegendruckbetrieb, Zeichnung 101-500505-4002
6. Dampf- und Kraftmengen, Kondensationsbetrieb, Zeichnung 101-500505-4003
7. Elektrische Krafterzeugung, Zeichnung 101-500505-4004
8. Jährlicher Wärmeverbrauch in Dampf, Zeichnung 101-500505-4005
9. Berechnung von Kapitalinvestierung für Ausbau der Kraftzentrale

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6.7.72

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Banja Luka

Wärme- und Dampfverbrauch

Speisewasser 143°C, Frischwasser 10°C

Dampf 12 atü	Enthalpie		Wärme	Dampf	Kondensat		Speise-Wasser Wärmung
	Kondensat	Differenz					
13 ata, 210°C 680 kcal/kg	kcal/kg	kcal/kg	Gcal/h	t/h	%	t/h	Gcal/h
Kocherei 15,5 tz/h	FW 10	670	9,38	14,0	0	0	1,86
Laugebrenner	FW 10		4,69	7,0	0	0	0,93
Σ			14,07	21,0			2,79
Dampf 6,5 atü							
7,5 ata, 175°C, 665 kcal/kg							
Zellwolle	FW 10	665	2,69	4,1	0	0	0,55
HWM	FW 10	665	8,71	13,3	0	0	1,77
Zellophan	FW 10	665	1,38	2,1	0	0	0,28
CS_2	FW 10	665	0,46	0,7	0	0	0,09
Anhydrid	FW 10	665	2,55	3,9	0	0	0,52
Zubearb.Zellophan	90	575	1,59	2,6	50	1,3	0,23
Papierfabrik	90	575	2,95	5,0	80	4,0	0,34
Polyesterfabrik	90	575	2,95	5,0	80	4,0	0,34
Gasbetonfabrik	FM 10	665	3,33	5,0	0	0	0,67
Σ			26,61	41,7		9,3	4,79

Dampf 3,5 atü 4,5 ata, 160°C, 663 kcal/kg	Enthalpie Kondensat kcal/kg	Enthalpie Differenz kcal/kg	Wärme Gcal/h	Dampf t/h	Kondensat %	Kondensat t/h	Speise-Wasser Wärmung Gcal/h
Kocheri 15,5 tZ/h	FW 10	653	3,92	6,0	0	0	0,80
Eindampfanlage 56 % TS	141	522	16,89	32,0	95	30,4	0,27
Trockenanlage	141	522	11,09	21,0	95	20,0	0,17
"	141	522	1,09	2,0	85	1,7	0,04
Bleicherei	FW 10	653	13,70	21,0	0	0	2,79
Warmwasser 70°C	141	522	2,11	4,0	95	3,8	0,04
Zellwolle	100	563	23,96	39,0	44	17,0	3,66
HWM	100	563	22,68	37,5	53	20,0	3,19
Zellophan	100	563	10,27	16,6	39	6,4	1,64
CS_2	FW 10	653	1,90	2,9	0	0	0,39
Wasseraufbereitung	FW 10	653	0,33	0,5	0	0	0,07
Zubearb.Zellophan	100	563	1,52	2,5	50	1,25	0,22
Σ Sommerzeit			109,46	185,0		100,6	13,28
Klimaanlagen Winterzeit							
Viskose + Zellophan	80	583	13,39	22,4	80	17,9	1,73
Zubearb.Zellophan	80	583	1,79	3,0	80	2,4	0,23
Winterheizung							
Zellstoffabrik + Elektrolyse	80	583	1,79	3,0	80	2,4	0,23
Lab. Werkst.Büro	80	583	3,58	6,0	80	4,8	0,46
Σ Zusätzl. Winterzeit			20,55	34,4		27,5	2,65
Σ Σ Winterzeit			130,01	219,4		128,1	15,93
Summe alle Verbraucher							
Sommerzeit			150,14	247,7		109,9	20,86
Speiserwasserwärmung 3.5 atü	143	520	(20,86)	40,2	100	40,2	0
Σ Sommerzeit			150,14	287,9		150,1	20,86
Winterzeit			170,69	282,1		137,4	23,51
Speiserwasserwärmung 3.5 atü	143	520	(23,51)	45,2	100	45,2	0
Σ Winterzeit			170,69	327,3		182,6	23,51

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Beilage 2

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Banja Luka

Elektrische Kraftbilanz

Elkraftverbrauch im Mittel	Produktion t/Jahr	Ausnützungs-Zeit h/Jahr	Leistung MW	Energi GWh/Jahr
Zellstoff-Fabrik 15,5 tZ/h à 850 kWh/tZ	124 000	8 000	13,2	106
Elektrolyse 1 t NaOH/h à 3 800 kWh/t NaOH	8 000	8 000	3,8	30
Viskosefabrik		8 000	10,0	80
- Zellwolle 50 t/Tag	16 700	8 000		
- HWM 25 t/Tag	8 300	8 000		
- Zellophan 10 t/Tag	3 330	8 000		
Papierfabrik	5 000	7 000	1,0	7
Polyesterfabrik	?	8 000	3,3	27
Gasbetonfabrik	?	8 000	0,8	6
Wasserstationen		8 000	4,0	32
Kraftwerk		8 000	3,0	24
Σ			39,1	312
Geschätzte max. Leistung			47	

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6.7.72

Fabrika Celuloze i Viskoze

Banja Luka

Erzeugung von Kraft

Erzeugung im Mittel		Sommer			Winter		
1. Nur Gegendruckbetrieb							
Kessel im Betrieb		P2	60	t/h	P2	50	t/h
		P3	60	"	P3	50	"
					P4	50	"
	Σ Vorhandene Kessel		120	t/h		150	t/h
		P5	156	"	P5	164	"
		Σ	276	t/h		314	t/h
Krafterzeugung		T1	4,1	MW	T1	4,1	MW
		T2	16,0	"	T2	16,0	"
		T4	16,7	"	T4	23,4	"
		Σ	36,8	MW		43,5	MW
2. Voller Kondensationsbetrieb							
Kessel im Betrieb		P2	65	t/h	P2	65	t/h
		P3	65	"	P3	65	"
		P4	65	"	P4	65	"
	Vorhandene Kessel		195	t/h		195	t/h
		P5	179	"	P5	181	"
		Σ	374	t/h		376	t/h
Krafterzeugung		T1	4,1	MW	T1	4,1	MW
		T2	13,5	"	T2	13,5	"
		T3	13,5	"	T3	13,5	"
		T4	25,7	"	T4	25,7	"
		Σ	56,8	MW		56,8	MW

BEILAGE 4

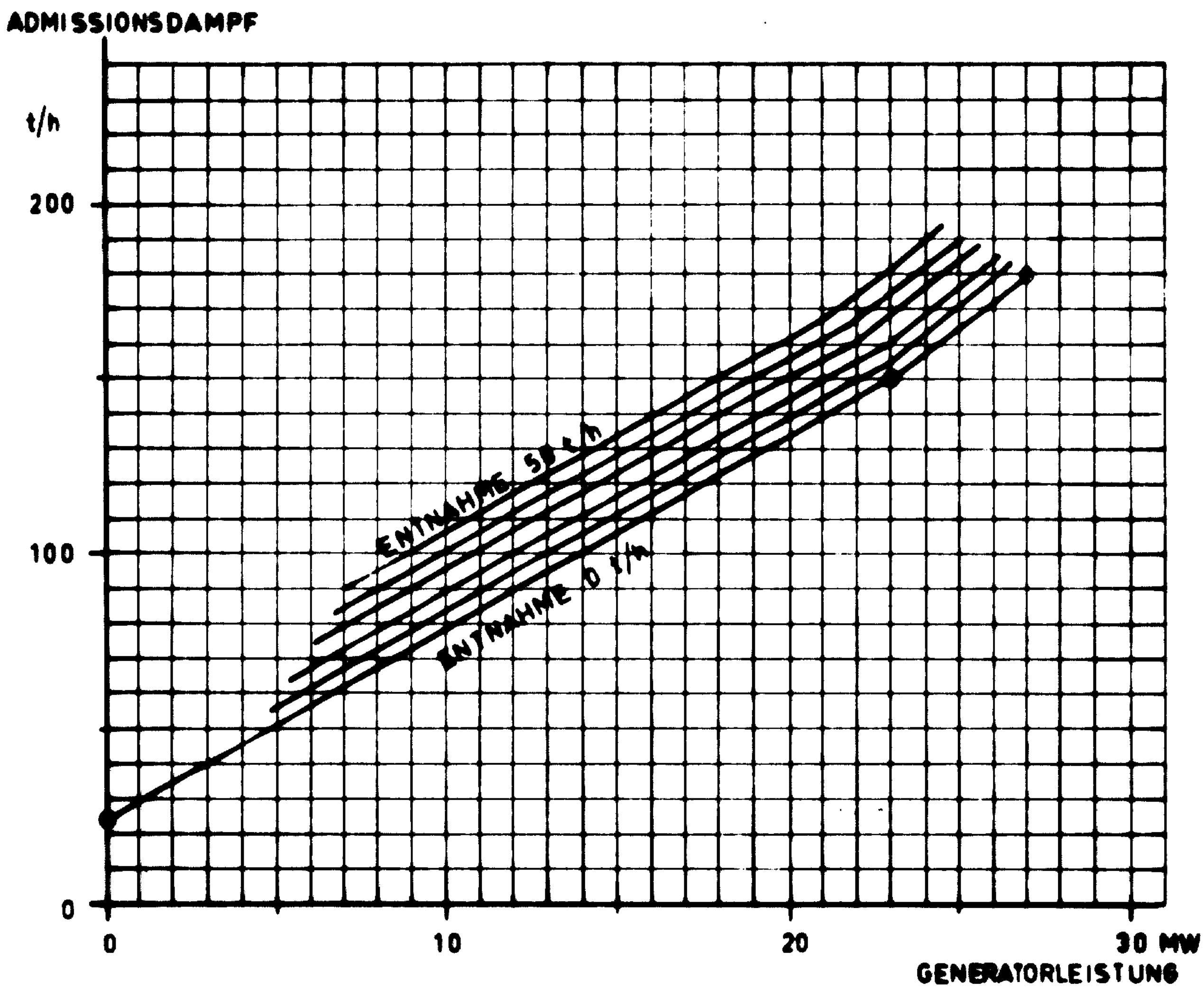
ADMISSIONSDAMPF

DRUCK	71 atü
TEMPERATUR	515 °C
VOLLASTMENGE	150 t/h

ENTNAHME

DRUCK	14 atü

GEGENDRUCK	5 atü
MAX. GENERATORLEISTUNG	27 MW



REV.	REV. AVSER	SIGN.	GODK	DATUM

ENERGIKONSULT
STOCKHOLM
SWEDEN

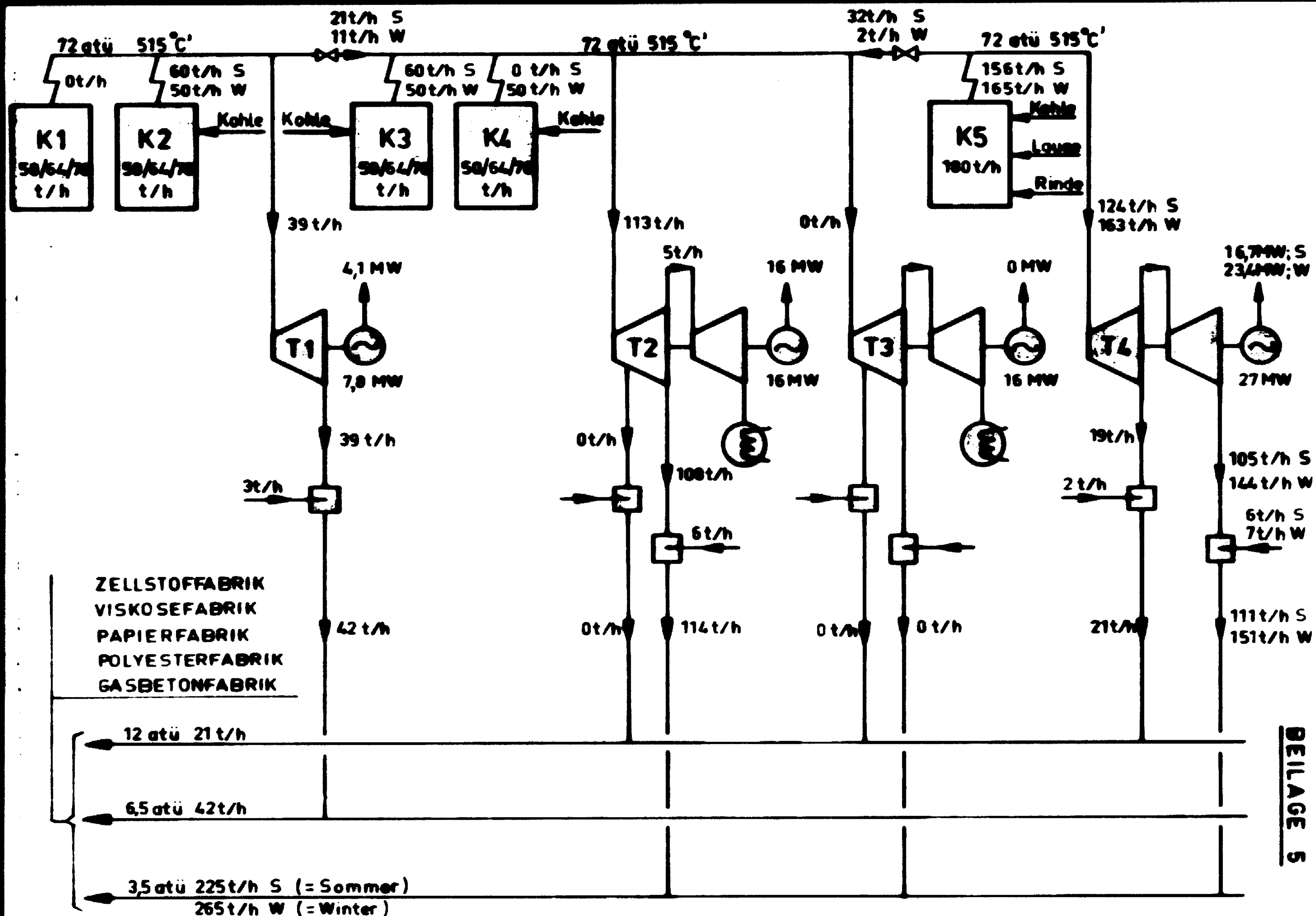
FABRIKA CELULOZE I VISKOZE
BANJA LUKA
AUSLEGUNG VON GEGENDRUCKTURBINE T4

RIT DEN	KONSTR.	GRANSK.
ST		

GODK	PROJ.L.		SKALA
4 7 72	GRELS BERG		

RITN.NR	REV.	ARB.NR	RITN.NR	REV.
101-900501-4001				

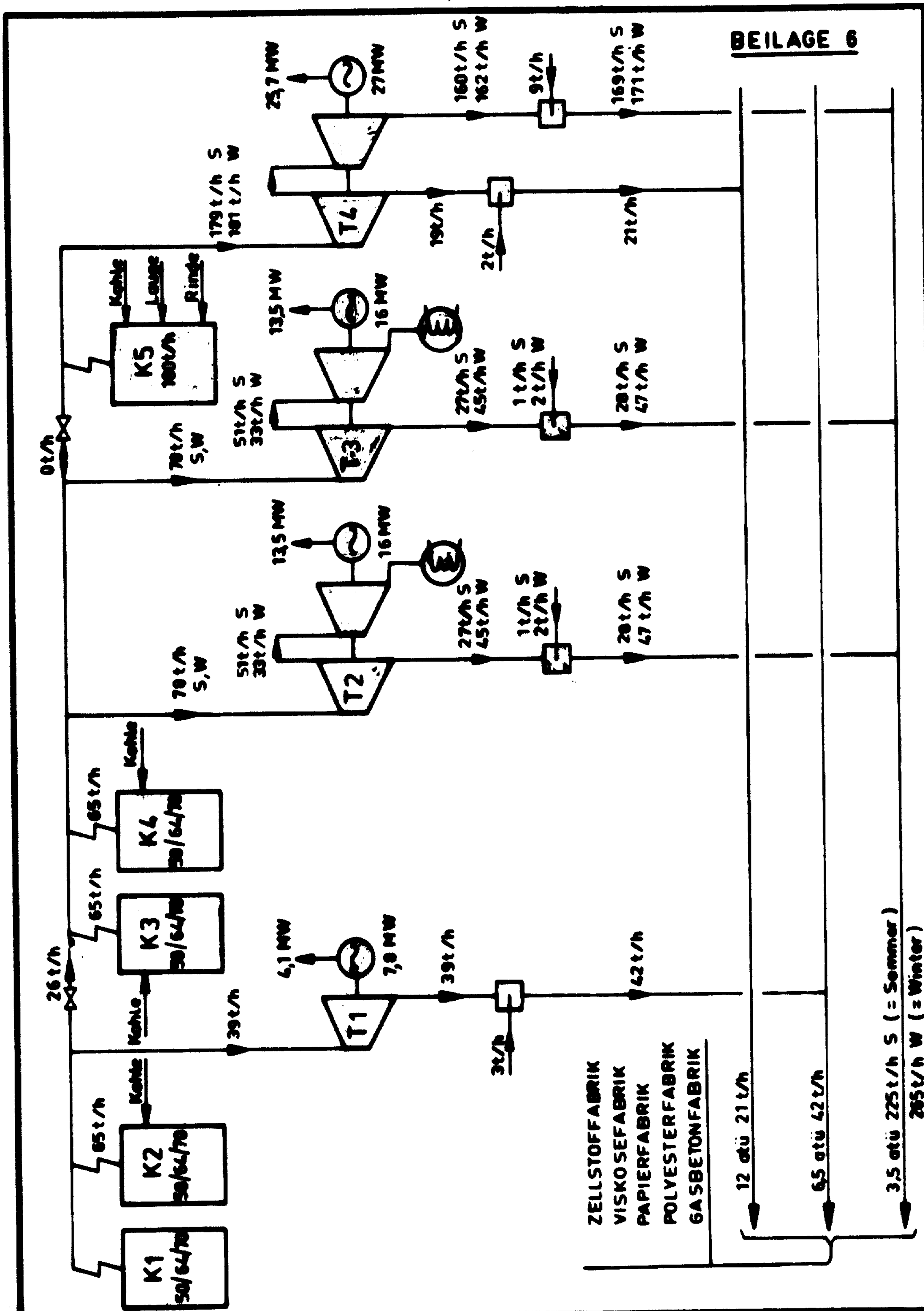
BEILAGE 5



ENERGIKONSULT STOCKHOLM SWEDEN	FABRIKA CELULOZE I VISKOZE BANJA LUKA DAMPF- und KRAFTMENGEN NUR GEGENDRUCKBETRIEB MIT T 2 und T 3	Rit: MW — STHLM d. 4/7-72 Check: GRELS BERG Godk: — Journ: — Skala: Ritn nr 101-900501-4002

AA. Bokulunds, Sthlm. 4.72. 1000 ex. Pyramid 21 81088

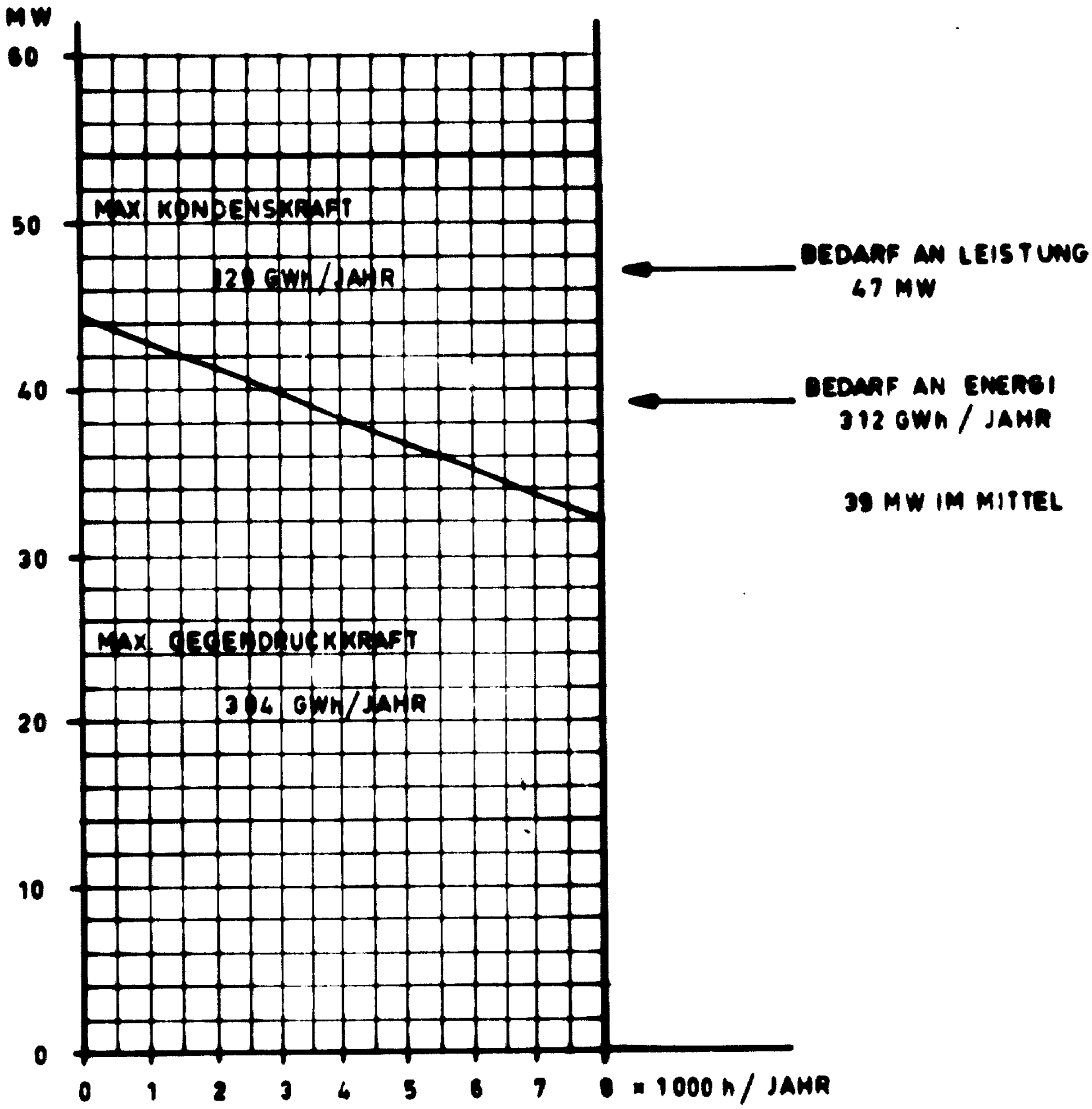
BEILAGE 6



ENERGIKONSULT STOCKHOLM SWEDEN	FABRIKA CELULOZE I VISKOZE BANJA LUKA DAMPF-und KRAFTMENGEN VOLLER KONDENSBETRIEB MIT T2 und T3	Rit MW	STHLM. 4 7-72
		Check	GRELS BERG
		Godk	Journ / Skala
		Ritn nr 101-900501-4003	

AB. Berklunds, Sthlm. 4 72. 1000 ex. Pyramid 21 81688

BEILAGE 7



REV.	REV AVSER	SIGN	GODK	DATUM

ENERGIKONSULT
STOCKHOLM
SWEDEN

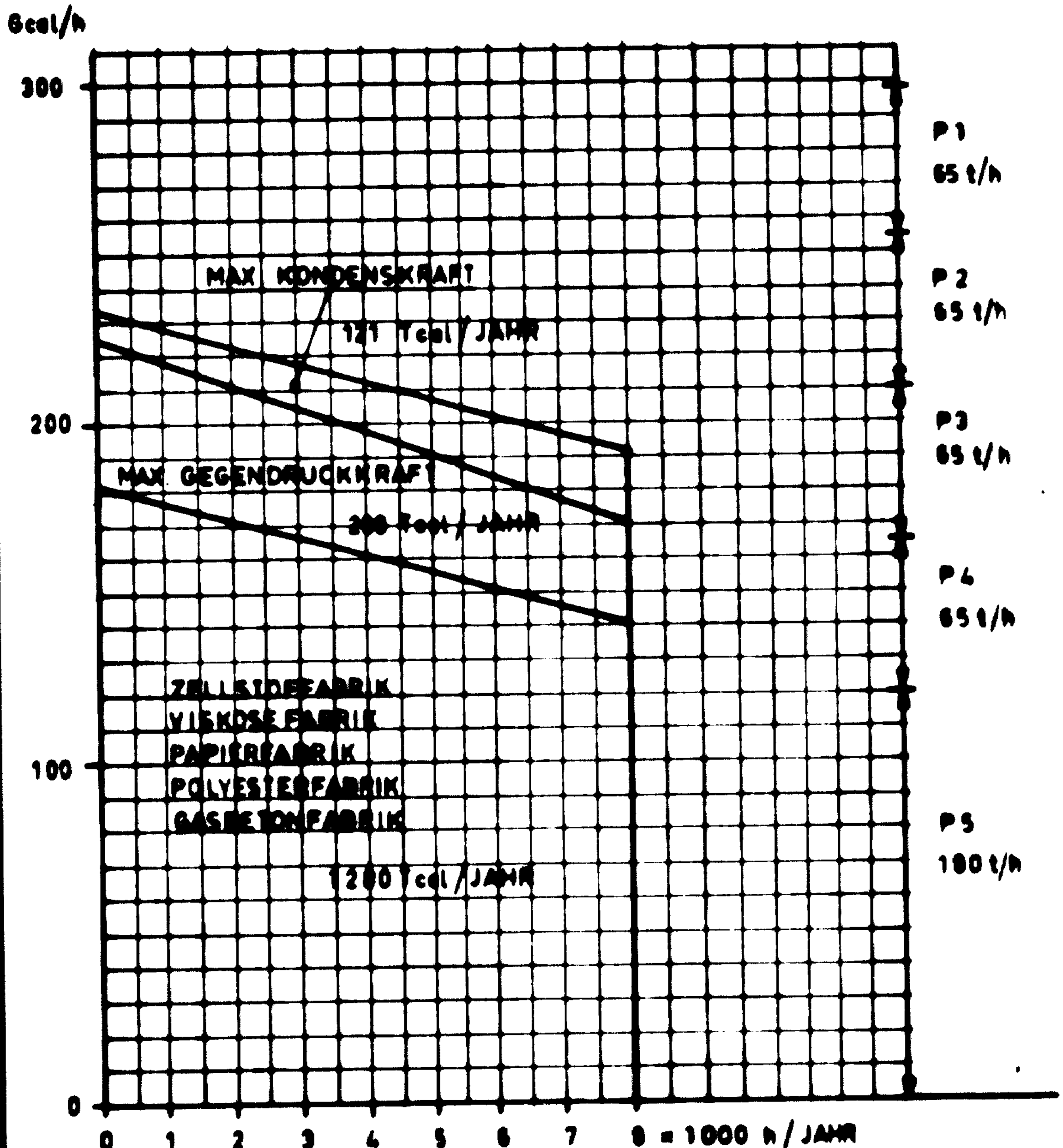
FABRIKA CELULOZE I VISKOZE
BANJA LUKA
ELEKTRISCHE KRAFTERZEUGUNG
TURBINEN T1, T2, T3, T4 IM BETRIEB

RIT. DEN	KONSTR.	GRANSK.
ST		
GODK 4.7.72		PROJ.L. GRELS BERG

SKALA

RITN.NR	REV	ARB NR	RITN.NR	REV
101-900501-4004				

BEILAGE 9



REV.	REV. AVSER	SIGN.	GODK.	DATUM

ENERGIKONSULT
STOCKHOLM
SWEDEN

FABRIKA CELULOZE I VISKOZE BANJA LUKA

JÄHRLICHER WÄRMEVERBRAUCH IN DAMPF

RIT. DEN	KONSTR.	GRANSK.
ST		
GODK. 4.7.72		PROJ.L. GRELS BERG

RITN.NR	REV	ARB.NR	RITN.NR	REV	SKALA
101-900501-4005					

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Beilage 9

900501
P-Beg/DS
6.7.72

Fabrika celuloze i viskoze, Banja Luka

Berechnung von Kapitalinvestierung für Ausbau der Kraftzentrale

A. Voraussetzungen

1. Preisstellung, Gleitpreis vom 1.5.72.

2. Die Preise unten umfassen komplette Geräte mit Montage und nötiger Hilfsausrüstung mit elektrischen Motoren. Für Rohrleitungen umfasst der Preis Armaturen, Isolierung und Konsolen. Für äussere Rohrleitungen ist vorausgesetzt worden, dass Rohre an vorhandenen Pfeilern befestigt werden können.

3. Die Preise basieren sich auf schwedische Verhältnisse. Die Umrechnung zu jugoslawischen Verhältnissen ist basiert auf 1 Skr = 3.1 Din.

4. Die Gebäudekosten sind gerechnet, vorausgesetzt dass die Grundarbeiten für normale Kosten ausgeführt werden können.

5. Die Dampfleitungen bis zum Verbraucher in der Zellstoffabrik sind in den Berechnungen eingeschlossen.

6. Die Verteilung von elektrischer Kraft ist bis zum 20 kV Schaltanlage in der Kraftzentrale eingeschlossen.

7. Die Beförderung von Rinde und Kohle ist nur innerhalb der Kraftzentrale berücksichtigt.

8. Es ist vorausgesetzt, dass der vorhandene Schornstein auch für den neuen Kessel K5 ausreicht.

9. In den allgemeinen Kosten sind eingeschlossen, Administration während der Bauzeit, Konsulten und Kontrollanten sowie Inbetriebnahme. Die Kosten für Inbetriebnahme umfassen nur die normalen Kosten; unnormale Kosten, die grobe Fehler der Anlage oder lange Lieferungsverspätungen verursachen, sind nicht berücksichtigt. Zinsen während der Bauzeit, Inflation, Steuern und Zollen sind nicht berücksichtigt.

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B. Berechnungen

1. Kesselanlage

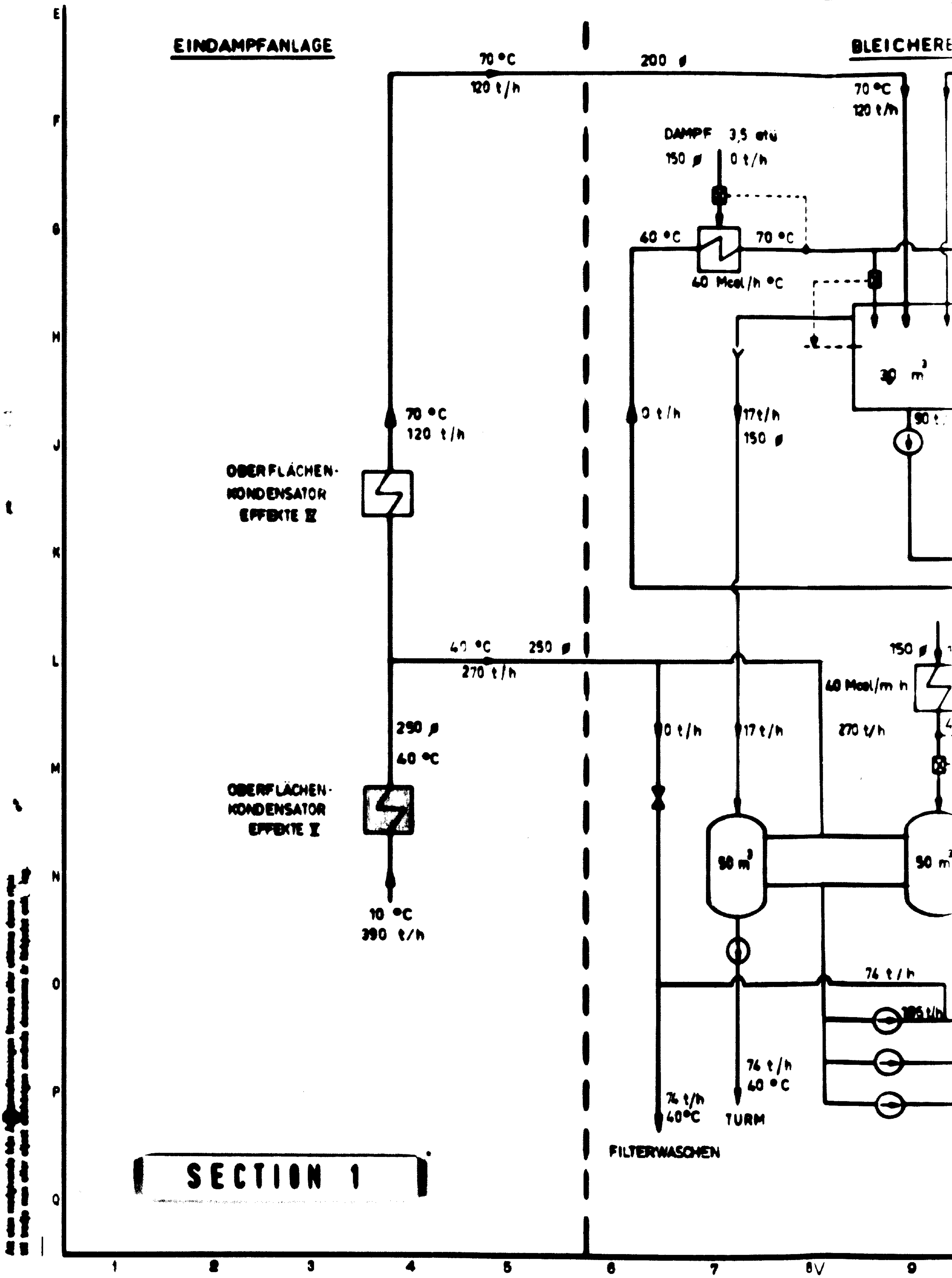
	MDin
Dampfkessel K5, 180 t/h, 87 atü, 515/525°C 143°C, für Kohlenstaub, Sulfitlauge und Rinde, einschliesslich Kohlenstaubmühlen	45,0
Elektrofilter	8,0
Speisepumpen für Vollast ausgelegt, zwei elektrische und eine dampfgetriebene	3,0
Speisewasserbehälter 120 m^3 mit Regulatoren	1,0
Laugeleitungen hin und rück zwischen Eindampf-anlage und Kraftzentrale 2 x 150 m, 80 bzw. 60 mm ∅	0,3
Laugepumpen 2 x 50 m^3/h	0,4
Rindebehälter 400 m^3 und Rindeförderer im Kesselhaus	1,8
Kohleförderer im Kesselhaus	3,0
Rohrleitungen für Wasser und Dampf im Kesselhaus	6,0
Dampfreduzier- und Kühlstationen	1,0
Dampfleitung 12 atü, 150 m, 250 mm ∅ nach Kocherei	0,3
Instrumentierung und Automatik	9,0
Kleinere nicht spezifizierte Geräte	4,2
Elektrische Installationen einschl. Beleuchtung	3,0
Gebäude mit Warteraum einschl. Behälter für Kohle, Kesselhaus jedoch nur mit Dach für den Kessel; 40 000 m^3	12,0
Ventilation und Heizung	1,0
Administation während Bauzeit	2,0
Konsulten und Kontrollanten	6,0
Inbetriebnahme	2,0
	109,0

2. Turbinenanlage	MDin
Gegendruckdampfturbine T4, 27 MW einschl. Generator 10 kV, 36 MVA	15,0
Transformator, 36 MVA, 10/20 kV	1,5
Schaltanlage 20 kV	0,8
Übrige elektrische Ausrüstung	1,2
Gegendruck- und Entnahmeleitungen im Turbinenhaus	4,0
Instrumentierung im Warteraum	1,5
Kleinere nicht spezifizierte Geräte	2,0
Gebäude mit Turbinenfundament, 13 000 m^3	6,0
Administration während Bauzeit	0,6
Konsulten und Kontrollanten	1,8
Inbetriebnahme	0,6
	35,0
Gesamtbetrag	144,0

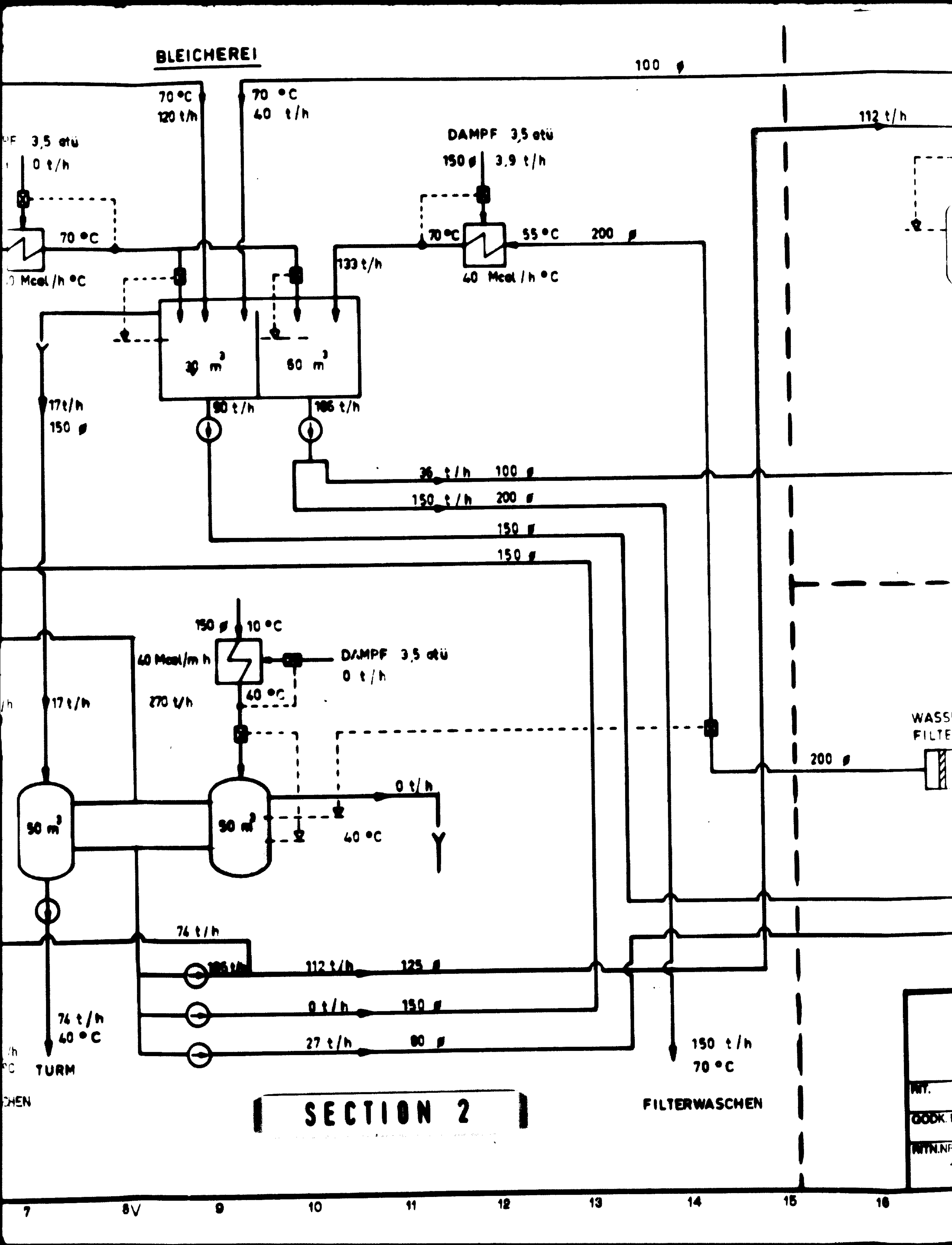
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, VIENNA
CONTRACT 71/50

Report 1 REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"

Appendix 2 Proposal to warm water supply in the pulp mill



EINDAMPFANLAGE
BLEICHERE
70 °C
120 t/h
200 ⌀
70 °C
120 t/h
DAMPF 3,5 atü
150 ⌀
0 t/h
40 °C
70 °C
40 Mcal/h °C
30 m³
70 °C
120 t/h
0 t/h
17 t/h
150 ⌀
OBERFLÄCHEN-
KONDENSATOR
EFFEKTE II
40 °C
250 ⌀
270 t/h
150 ⌀
40 Mcal/m h
250 ⌀
40 °C
0 t/h
17 t/h
270 t/h
OBERFLÄCHEN-
KONDENSATOR
EFFEKTE I
50 m³
50 m³
10 °C
390 t/h
74 t/h
74 t/h
40 °C
74 t/h
40 °C
TURM
FILTERWASCHEN
SECTION 1


BLEICHEREI
100 ø
70 °C
120 t/h
70 °C
40 t/h
112 t/h
DAMPF 3,5 atü
150 ø
3,9 t/h
3,5 atü
0 t/h
70 °C
55 °C
200 ø
70 °C
Mcal/h °C
133 t/h
40 Mcal/h °C
m³
60 m³
17 t/h
150 ø
90 t/h
166 t/h
36 t/h
100 ø
150 t/h
200 ø
150 ø
150 ø
150 ø
10 °C
40 Mcal/m h
DAMPF 3,5 atü
0 t/h
17 t/h
270 t/h
40 °C
WASS
FILTE
200 ø
50 m³
50 m³
0 t/h
40 °C
74 t/h
112 t/h
125 ø
0 t/h
150 ø
27 t/h
80 ø
74 t/h
40 °C
TURM
150 t/h
70 °C
FILTERWASCHEN
SECTION 2
INT.
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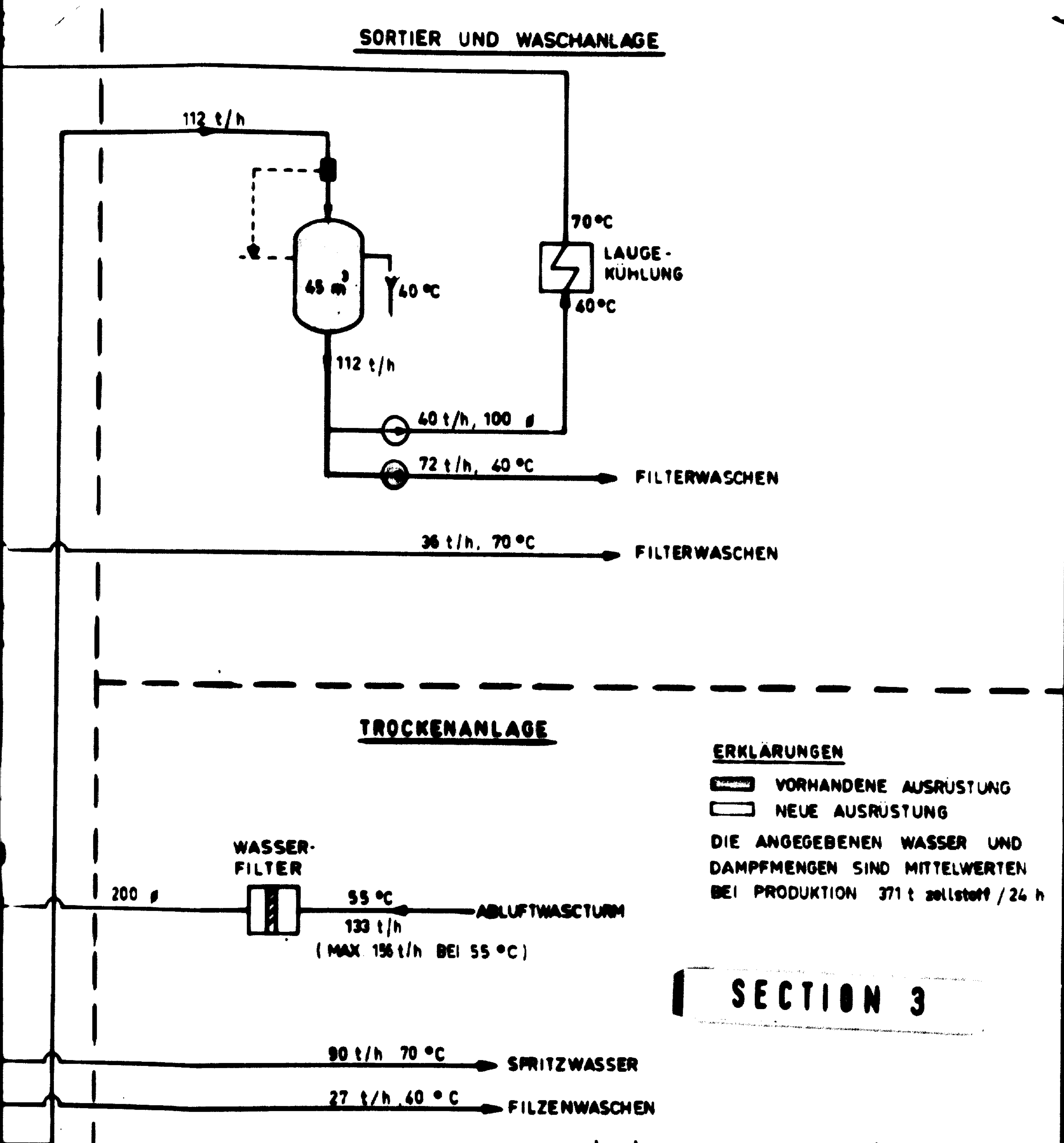

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ENERGIKONSULT

BANJA LUKA

VORSCHLAG FÜR WARMWASSERVERSORGUNG
40 °C UND 70 °C

UPPR. MD	KONSTR.	GRANSK.
GODK. DEN 4.10.72		PROJ.

SKALA

RITN.NR 101 - 900501 - 2001 | REV.

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, VIENNA

CONTRACT 71/50

Report 1 — REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELULOZE I VISKOZE, BANJA LUKA,

Appendix 3 — Report of 9 Nov. 1972. Standards and specifications for electrical equipment and installations

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Fabrika Celuloze i Viskoze
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Standards and specifications for
electrical equipment and installations

Energikonsult 1972-09-11
Electrical department
Sven Dagberg

Index

Drawings

No. 103-900501-

3001	Draft plan for the extension of the high voltage distribution	
3002	Low voltage switchgear.	Principle design
3003	Principle diagram for connection of control cables	
3004	Principles for marking of internal and external connections	
3005	Type diagram.	Motor starters for small motors
3006	" " .	Motor starters with auxiliary relay for big motors
3007	Coordination table motors-fuses-cables	

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900501.02
E-SDg/Os
1972-09-06

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Banja Luka (FCVBL)

Electric connection of new turbo-alternator

It is not possible to connect a new 35 MVA turbo-alternator to the existing 6.3 kV switchgear without taking measures to limit the short circuit power. There will also probably be problems with overloaded busbars.

The problem with short circuit power can at short sight be solved with an I_s-limiter in combination with a distribution of the feeders among the busbars. It will however be necessary to count with further enlargements in the future and also with a strengthening of the connection with the external network and then this solution will not be sufficient.

We therefore suggest that the new alternator and also new loads will be connected to a new 22 kV switchgear. A proposal for the enlargement of the high voltage distribution system is shown in drawing no. 103-900501-3001. We count upon this existing 35 kV feeder being changed in the future to a new 110 kV feeder.

The suggested enlargement can be made without any considerable changes in the existing switchgear and lays a good foundation for further enlargements.

An alternative solution would be to use the existing 35 kV switchgear but that solution has certain weaknesses. The room for enlargement is limited. It has only one busbar and it is difficult to install a second one. Finally 35 kV is no standard voltage according to IEC (IEC 38 1967 "IEC standard voltages").

The short circuit power in the 6.3 kV switchgear will anyhow rise above 500 MVA if no measures are taken. The easiest way would be to connect the existing alternators to different busbars and interconnect the busbars with an I_s-limiter.

It will be necessary to decide on this question before ordering the new alternator.

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Reconstruction of substations

General

In connection with the reconstruction of the pulp mill it will be necessary to make substantial changes of the substations and the electrical installations.

In the existing plant the motor starters are placed in sub-distribution boards located on different places in the factory near the motors. The sub-distribution boards are connected to metal-enclosed switchgear with switches and/or fuses located in the substations together with the transformers and the high voltage switchgears.

Many sub-distribution boards are located on places where the conditions are most unsuitable for electrical equipment and also for maintenance work. To reach a better reliability and better conditions for maintenance work the existing sub-distribution boards and distribution panels ought to be replaced by low voltage switchgears located in the substations. All substations ought to be equipped with a ventilation system designed to keep the rooms under pressure with filtered air and prevent corrosive atmosphere and dust to penetrate into them.

The number of transformers that will be required in the different substations is accounted for in the load calculation tables.

The technical standards for the switchgears are presented in the document "Technical requirements for electrical equipment and installations".

To make references to the specifications from NMW and the drawings from FCVBL easier the German and Jugoslavian names have been used below for the different departments and substations.

Abt. 1. Holzaufbereitung

TS Entrindung (Ljuštiona)

A new substation will be built together with the new building for chippers and chip blower. It will replace the existing substation which cannot be enlarged due to lack of room.

TS Holzhackerei (Sjeknona)

The existing low voltage distribution switchboard will be exchanged to a new switchgear with motor starters. To keep the room free from dust it will be necessary to locate the control board outside the switchgear room so the door can be kept closed.

Abt. 2-6. Kocherei, Wasch- & Sortieranlage, Bleicherei, Trockenanlage, Kochsäureaufbereitung

TS Kocherei (Kuhaona)

This substation from which Kocherei, Wasch- und Sortieranlage, Kochsäureaufbereitung and parts of the Bleicherei will be fed has to be enlarged. The old distribution switchboards will be replaced by new switchgear with motor starters located on the floor above the existing substation. A new transformer cell for one transformer will be built.

TS Bleicherei (Bjeliona)

It will be necessary to improve the building to prevent water from penetrating into the room through the cable channels and to prevent condensing water to drip onto the electric equipment from the insufficiently insulated ventilation channels in the roof.

TS Trockenanlage (Susiona)

As the existing substation will be too small and is difficult to enlarge, a new substation will be built in connection with the machine building.

TS Eindampfanlage (Uparivaona)

The electric equipment in this department is now fed from TS Kokerei. Owing to the extension of the factory it will be necessary to build a new separate substation for the Eindampfanlage outside the building.

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Addition of loads according to preliminary motor lists from KMW (Project BL C-I/ca)

Department	Voltage V	Existing No. of motors	Existing Connected load kW	Additional No. of motors	Additional Connected load kW	Total No. of motors	Total Connected load kW
1. Holzaufbereitung	380	55	1 780	74	625	129	2 405
	6 300	-	-	2	675	2	675
						131	3 080
2. Kocherei	380	20	675	1	2	21	677
3. Wasch- und Sortieranlage	380	36	817	24	1 233	60	2 050
4. Bleicherei	380	113	2 999	16	659	129	3 658
	6 300	2	480	-	-	2	480
						131	4 138
5. Trockenanlage	380	-	-	224	2 968	224	2 968
	DC	-	-	16	361	16	361
						240	3 329
6. Kochsäureaufbereitung	380	7	376	3	250	10	626
7. Eindampfanlage	380	22	693	11	625	33	1 318
Total	380	253	7 340	369	6 723	622	14 063
	6 300	2	480	2	675	4	1 155
		255	7 820	371	7 398	626	15 218

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Load distribution among the substations

Substation	Voltage V	Connected load kW	Max. demand kW	Max. demand kVA	
"Entrindung"	380	1936	1350	1900	Equipment at debarking plant and chip store
"	6300	675			
"Holzhackerei"	380	472	330	460	Equipment at chip silo
"Kocherei"					
Dept. Kocherei	380	677			+) The distribution of the loads among substations "Kocherei" and "Bleicherei" is not definite
" Wasch & Sortier	380	2050			
" Kochsäure	380	626			
" Bleicherei +)	380	1670			
	380	5023	3500	4900	
"Bleicherei"					
Dept. Bleicherei +)	380	2000			
" Trockenanlage	380	605			Zellstoffaufbereitung
		2605	1800	2500	
" Bleicherei	6300	480			
"Trockenanlage"	380	2721	1900	2600	excl. Zellstoffbereitung
"Eindampfanlage"	380	1318	900	1250	

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Required transformers 6300/400 or 21000/400 V

This table contains the necessary minimum requirements according to the preliminary motor lists from KMW, Project BL C-I/ca. It has to be reviewed when definite motor lists are ready. Reserve capacity is not included.

Substation	Estimated load at 400 V kVA	Transformers Existing	Transformers Required min.	Change
Entrindung	1 900	1x1000 kVA	2x1000 kVA	+ 1x1000 kVA
Holzhackerei	460	1x1000 kVA	1x630 kVA	-
Kocherei	4 900	4x1000 kVA	5x1000 kVA	+ 1x1000 kVA
Bleicherei	2 500	3x1000 kVA	3x1000 kVA	-
Trockenanlage	2 600	1x1000 kVA	3x1000 kVA	+ 2x1000 kVA
Eindampfanlage	1 250	-	1x1600 kVA	+ 1x1600 kVA
		10x1000 kVA	14x1000 kVA	+ 4x1000 kVA
			1x1600 kVA	+ 1x1600 kVA

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Technical requirements for electrical equipment and installations

General requirements

Regulations and standards

The electrical equipment and installations shall comply with the Yugoslavian Electrical Code and the IEC Recommendations or VDE Standards in named order. If the standard differs from this specification, the specification shall apply.

Adaptation to environment

The air in the plant contains corrosive gases, above all SO_2 and Cl and dust especially coal dust and soot.

Electric switch- and controlgear are for that reason normally to be installed in separate rooms with good ventilation.

Technical design

Standardization

The number of types and sizes of components shall be limited as much as possible to facilitate operation and maintenance work.

Motors shall be of IEC and DIN standard sizes.

Cables, fuses and motor starters are to be coordinated with the motors according to the coordination table, drawing no. 103-900501-3007.

Motor control circuits are to be standardized according to type diagrams, drawing nos 103-900501-3005 and -3006.

The low voltage switchgears are to be equipped with standardized interchangeable units containing switch, fuses, contactor (auxiliary relay, if any) and overload relay for each motor.

Item numbering and markings are to be standardized in agreement with the customer.

Voltages för motors

3-phase motors bigger than c. 200 kW:
6 300 V, 50 Hz

3-phase motors up to c. 200 kW:
380/220 V, 50 Hz, solidly grounded system

1-phase motors up to c. 0,5 kW:
220 V, 50 Hz, solidly grounded system

Control voltages

For contactors etc.: 220 V, 50 Hz with one pole grounded

For signal lamps: 48 V, 50 Hz

For high voltage (6,3 kV and above) switches: 110 V, DC

Grounding system

Protective grounding is to be made as "Nullung" according to VDE 0100/12.65 § 10 N.

Low voltage switchgears

For the distribution of low voltage, from the transformers there are to be installed metal-enclosed switchgears containing standardized interchangeable units for switches and fuses and for different sizes of motor starters.

Principles are shown in drawings nos 103-900501-3002 and -3003.

Rated voltage:		380 V, 50 Hz
Insulation level:		3 kV, 50 Hz, 1 min.
Short time withstand current:		40 kA RMS
Peak withstand current:		100 kA ampl.
Rated current of main busbars:		2 000 A
Degree of protection:	in substations	P 21
	elsewhere	P 43
Design:	according to the standard of the contractor. It is desirable that the above-mentioned units can be exchanged without voltage interruption on the busbars.	

The feeder cubicle is to be equipped with a manuelly operated main circuit-breaker, amperemeter, voltmeter with voltmeter switch, and push-button for tripping of the high voltage circuit breaker of the transformer.

Each switchgear is to be equipped with a separate fuse-board with main switch for distribution of the control voltage to the different cubicles according to drawing no. 103-900501-3003.

In substations containing more than one transformer there shall be arranged an interconnection with a normally open disconnector between the 400 V busbars as a reserve feeder by transformer failures and similar situations.

<u>AC motors</u>

These rules are to be applied to new motors. Existing motors may diverge from these rules.

AC motors are normally to be totally enclosed fan cooled squirrel-cage induction motors for direct-on-line starting.

Motors shall be designed, fabricated and tested in accordance with the latest editions of IEC standards or German VDE standards. All motors shall have IEC frame sizes.

The motor design shall normally allow at least three starts in quick succession from cold against full load without injurious heating of insulated windings.

Bearings shall preferably be ball and/or roller grease lubricated bearings.

Space heaters are to be provided for 6,3 kV motors. Supply voltage 220 V, 50 Hz. Space heater leads are to be brought out into a separate terminal box located near the main terminal box.

Degree of protection shall be at least P 33 for motors and P 43 for terminal boxes.

Safety switches for motors

To allow safe repair and maintenance work on motors and their corresponding machines all remote controlled low voltage motors are to be connected via manuelly operated safety switches. The safety switches shall be mounted in the immediate vicinity of the motors to avoid mistakes.

The safety switches shall:

1 be enclosed with degree of protection at least P 44

2 have a breaking capacity of at least 8 times the rated current of the motor at 110 % rated voltage and cos φ = 0,35

3 have a reliable position indicating device that safely shows the real positions of the contacts

4 in open position have a disconnecting air distance of at least 4 mm at 380 V

5 be possible to padlock in open and closed position

Control gear

Type diagram for motor control circuits are shown in drawings nos 103-900501-3005 and -3006.

The motors are to be controlled by control switches to show the ordered state of the motors. All signal lamps are normally dark but if a running motor is tripped by e.g. the thermal relay the signal lamp by the switch will start flashing and accoustical alarm will be given.

All interlocking and control circuits are to be connected in separate connection cabinets (or boxes) near the switchgears.

Components

The choice of components is to be approved by the buyer.

Fuses are to be standardized in consultation with the buyer.

Contactors are to be so dimensioned that they will not carry more than 75 % of their rated thermal current under normal conditions.

The rated thermal current of any contactor may not be less than 16 A.

Contactors are to be chosen according to at least the utilization category AC 3.

Thermal overload relays are to be installed for all motors. They shall be of plug-in type, have a separate auxiliary contact for alarm and be adjustable for manual or automatic reset.

Current transformers

Secondary current: 5 A

Amperemeters

The amperemeters for the feeders to substations and switchgears are to be equipped with a moving-iron mechanism and a 15 min. bimetallic mechanism with a trailing pointer to show the maximum demand.

Terminal boards

Terminals for measuring circuits shall be provided with an arrangement allowing an easy connection of control instruments without disconnecting wires. Terminals for current measuring circuits shall have an arrangemant for short-circuit.

Terminals in the separate coupling cabinets shall be isolating terminals to facilitate testing and trouble-shooting.

Normally only one conductor is allowed on the external side of each terminal. On the internal side two conductors are allowed on each terminal. All connections between terminals are to be done on the internal side. In each unit (panel, cubicle etc.) there shall be room for at least 10 % spare terminals or at least five terminals for future connection.

Cables and wires

The following types of cable are to be used:

Low voltage power cables indoors:	NYY
" " " " underground:	NYYBY
Control cables:	NYY
High voltage power cables:	N2YYBY

The cables are normally to be installed on cable racks or trays of galvanised steel (or equivalent). Installation in cable channels in the floors shall be avoided.

Internal control connections are to be made with PVC-insulated tin-plated 1,5 mm^2 wires.

Item numbering and marking

All equipment is to be provided with item numbers, which are to be found in specifications and drawings.

Cables shall be marked with cable numbers in both ends. Those cable numbers are to be found in cable lists and wiring lists (or diagrams).

Internal connections in cubicles, panels etc. shall be marked according to drawing no. 103-900501-3004 or equivalent. The marking are to be found in the corresponding lists and diagrams.

Markings, signs, warning boards etc. shall be of durable material and with text in the local language.

Drawings

Drawings for the electrical equipment shall be made according to DIN 40719 or equivalent standard. If the text is not in the local language there shall be space reserved for translation.

All dimensions shall be given in the SI system.

The following diagrams and drawings are to be delivered:

Erection drawings
List of equipment (preferred size: A3)
Block diagrams
Circuit diagrams (preferred size: A3)
Wiring lists or diagrams
Cable lists (preferred size: A3)
Position drawings
List of drawings

Drawings according to the real design and necessary instructions, descriptions etc. shall be delivered as soon as the equipment gets ready for service. One set of copies and documents shall be delivered for examination and approval in connection with the final inspection.

After that two sets of copies and one set of transparent final drawings are to be delivered in suitable covers.

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1973-01-09

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Technical requirements for synchronous generator and electrical equipment belonging to backpressure turbine

Standards and regulations

Generator and electrical equipment shall be made and tested according to IEC Recommendations and fulfil the requirements in Jugoslavian laws and regulations.

Generator and exciter

Rated power = the maximum output of the turbine, i.e. 12 alt. 23 MW

Power factor: 0,8

Frequency: 50 Hz

Rated voltage: 10 kV. The generator will be connected to 22 kV via unit transformer

Connection: Y-0 with both ends of all windings brought out to terminals

The generator shall be completely closed with a closed air cooling system with air/watercoolers. The housing shall be designed to make the stator windings accessible for cleaning. Proper inspection doors shall be placed where regular inspections are needed.

The stator windings shall be so designed that the replacement of a damaged coil can be carried out on the installation site and so that either end of the windings can be used as neutral point.

The generator shall be equipped with a connection box for cables or busbars with room for current transformers.

To permit temperature measurements at least 6 RTD's shall be placed in the slots on places where the highest temperatures may be expected and one in the cooling air after the cooler. The connecting wires shall be drawn to well marked detachable terminals in a common terminal box.

All bearings shall be provided with RTD's built into the bearing metal for temperature control and with pressure sensors for oil pressure control. The RTD's shall be connected to the above mentioned terminal box.

Precautions shall be taken against dangerous bearing currents. If such currents occur they shall be recorded. Electrical wiring for measuring of the bearing voltage shall be drawn into a connection box on the generator.

The generator shall be provided with a separate excitation rectifier fed from the auxiliary network or an AC exciter with rotating diodes.

The excitation system shall be complete and be provided with an automatic voltage regulator and manual control. Alternative excitation systems may be offered.

Protection system for the generator

The generator shall be provided with the following protection systems:

Differential protection
Stator earth fault protection
Interturn fault protection (if necessary)
Overvoltage protection
Stator overload protection
Reverse power protection
Over current protection or minimum impedance protection
Minimum voltage protection
Rotor earth fault protection
Assymetrical load protection
Diode supervision (only for rotating diodes)
Minimum frequency protection (turbine protection)

The protection relays are to be mounted in separate cabinets and be provided with arrangements for testing of all circuits and relays. There shall be indicating devices for visual indicating of occurring functions.

The delivery shall include the necessary measuring transformers and wiring for a complete protection system.

A neutral point equipment with resistor for limitation of the earth fault current to a harmless value, 10 A at solid earth fault, shall be included in the delivery.

Control panel

A control panel shall be installed in the existing control room. It shall contain the following equipment:

a) Control instruments for generator and exciter

b) Remote governor and indicator for field circuit breaker

c) Hand-automatic switch for voltage regulator

d) Switches (or similar) and instruments for adjustment of generator voltage

e) Push-buttons for speed control

f) Governing equipment for switching between backpressure and speed control

g) Temperature recording of all measuring points

h) Push button for emergency tripping of the aggregate

i) Annunciator for turbine and generator

Other electric equipment

Voltages for motors and control systems are prescribed in "Requirements for electrical equipment and installations".

In the delivery shall be included all necessary sensors and manoeuvring equipment for a complete security and alarm system.

In the delivery shall be included all electric motors inside the boundaries of delivery.

The turbine speed regulator shall be provided with a motor for turbine speed adjustment.

Switchgears with motor starters for all motors shall be included in the delivery.

In the turbine control panel to be included in the delivery shall be mounted push-buttons, switches, signal lamps etc. needed for start-up, normal run and shut down of the turbine.

Equipment mounted outside panels e.g. position switches, thermostats and similar shall be of closed design and placed accessible for inspection and adjusting during operation. It shall be designed and mounted regarding the vibrations which can occur and be suitably surface protected against possible chemical attack.

Marking. Drawings and descriptions

Labels, markings and drawings shall be made according to "Requirements for electrical equipment and installations".

A technical description of all electric equipment shall be included in the delivery. It shall in principle contain the following items.

General introduction

Description of function suitable for nonprofessionals

Detailed description of function suitable for electric service personnel

Attendance prescriptions i.a. lubrication instructions and service list for periodic maintenance

Instructions for fault searching

Instruction for installation

Spare parts list with proposal for spare storage list

Technical data, test reports, adjustment data etc.

Testing

The generator and exciter shall be tested in the contractors workshops and the following tests are to be made:

a) Overspeed test

b) No load and short circuit curves

c) Load point at rated voltage and current at power factor = 0 over excited

d) Control of the curve form of the voltage

e) Losses (type test report can be accepted)

f) Reactances - " -

g) Heat run - " -

h) Dielectric tests

j) Sudden short circuit test at rated voltage (only on special request)

The contractor shall keep the purchaser informed of the testing program and the purchasers representative shall be allowed to be present at the tests.

Boundaries of delivery

The delivery is limited by

a) the terminals of the generators

b) the feed point of switchgears and cabinets for auxiliary equipment

The delivery shall include delivery and installation of all cables between equipment included in the delivery.

Information from tenderer

Tenders shall contain the following data:

a) Temperature rise in stator and rotor windings at rated load

b) Description of windings and insulation.
Class of insulation

c) Reactances (X_d, X_d', X_d'') and short circuit ratio

d) Maximum reactive power output at power factor = 0

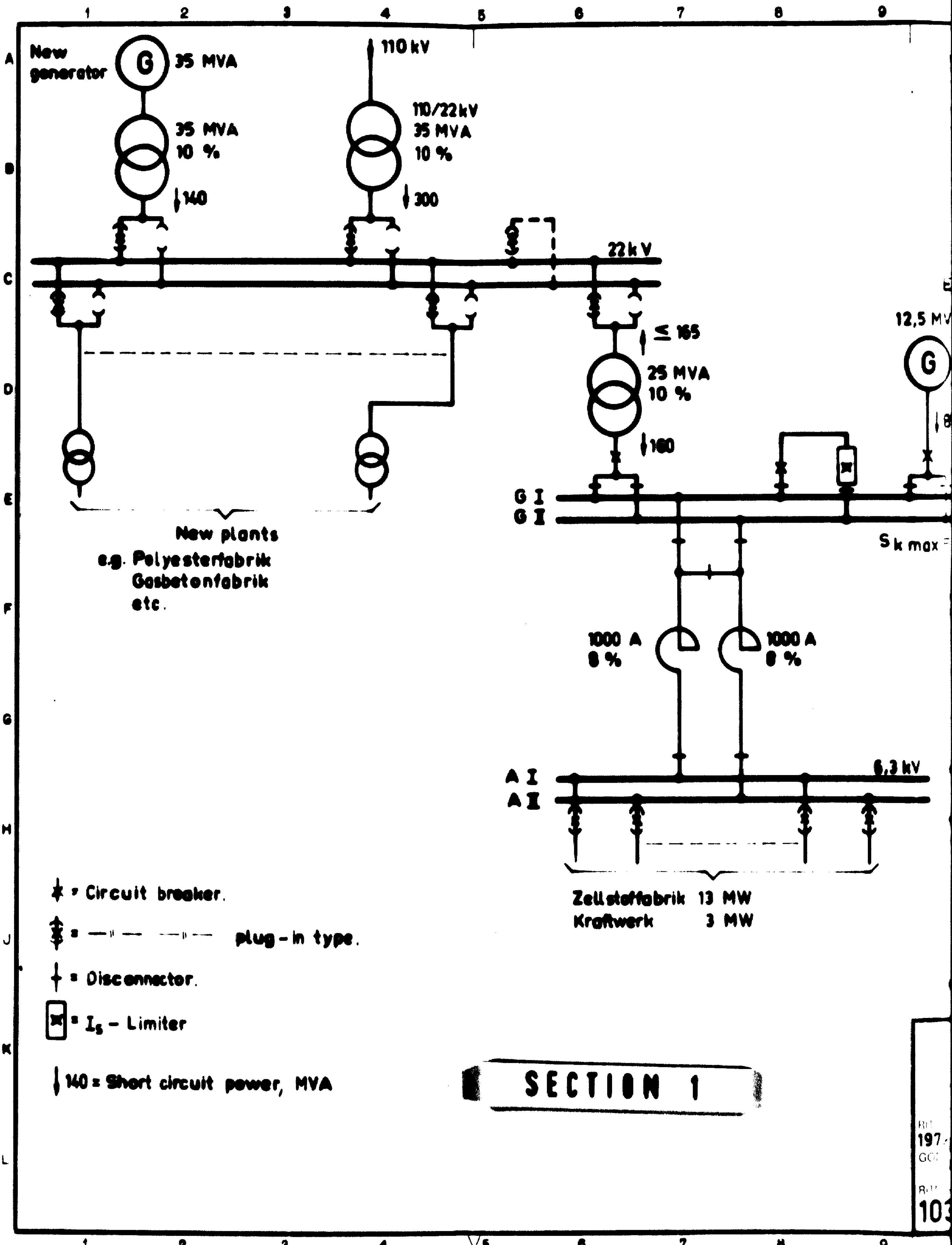
e) Possible deviations from specified standards

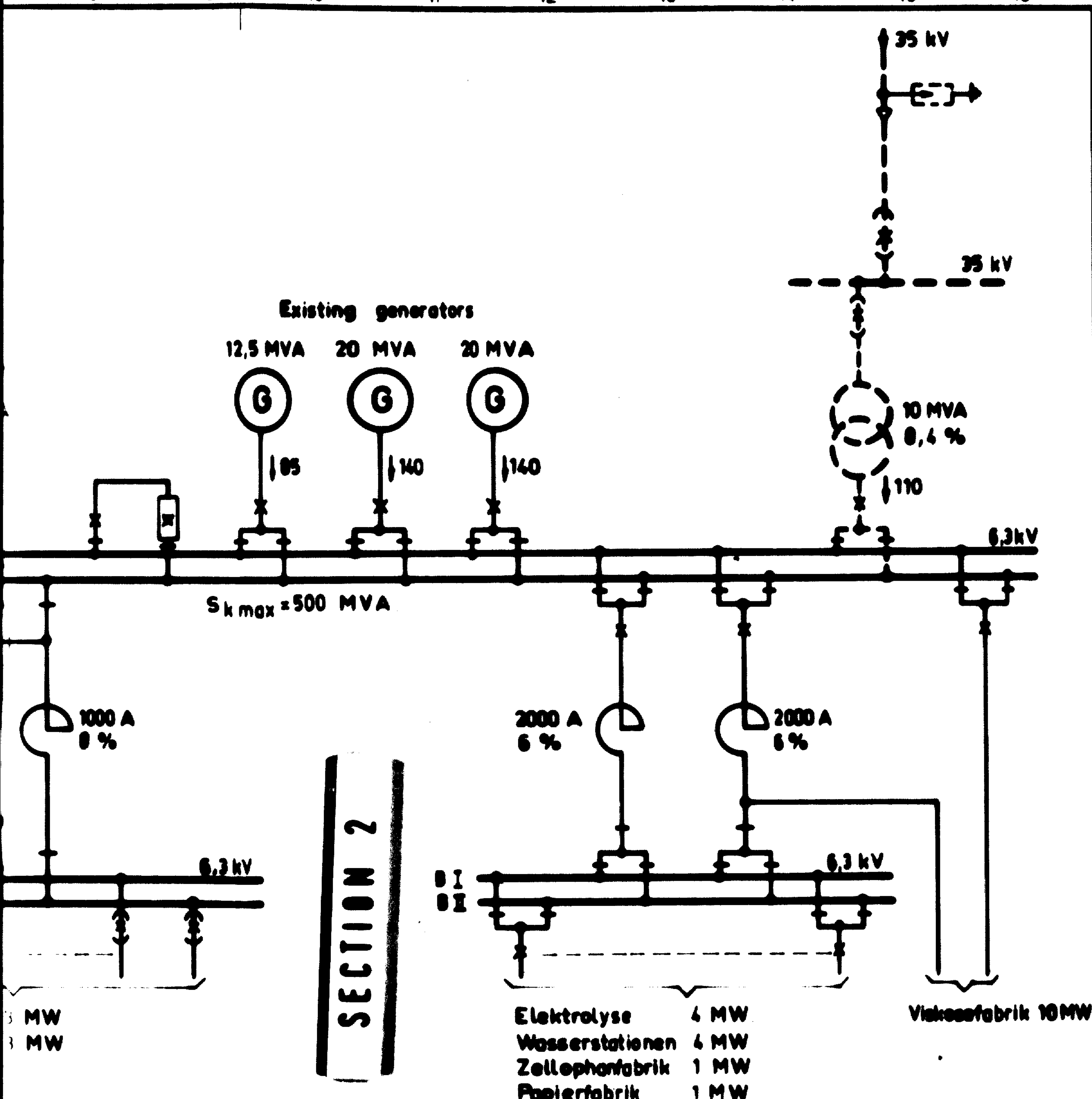
f) Technical description of excitation and supervision equipment

g) Power consumption for auxiliary equipment

h) Motor list

j) List of necessary spare parts with prices


New generator
G
35 MVA
35 MVA
10 %
140
110 kV
110/22 kV
35 MVA
10 %
300
22 kV
≤ 165
25 MVA
10 %
160
12,5 MV
G
G I
G II
S k max
New plants
e.g. Polyesterfabrik
Gasbetonfabrik
etc.
1000 A
8 %
1000 A
8 %
A I
A II
6,3 kV
Zellstoffabrik 13 MW
Kraftwerk 3 MW
= Circuit breaker.
= plug-in type.
= Disconnector.
= I_s – Limiter
140 = Short circuit power, MVA
SECTION 1
197
103



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FABRIKA CELULOZE I VISKOZE BANJA LUKA

DRAFT PLAN FOR THE EXTENSION OF THE HIGH VOLTAGE DISTRIBUTION

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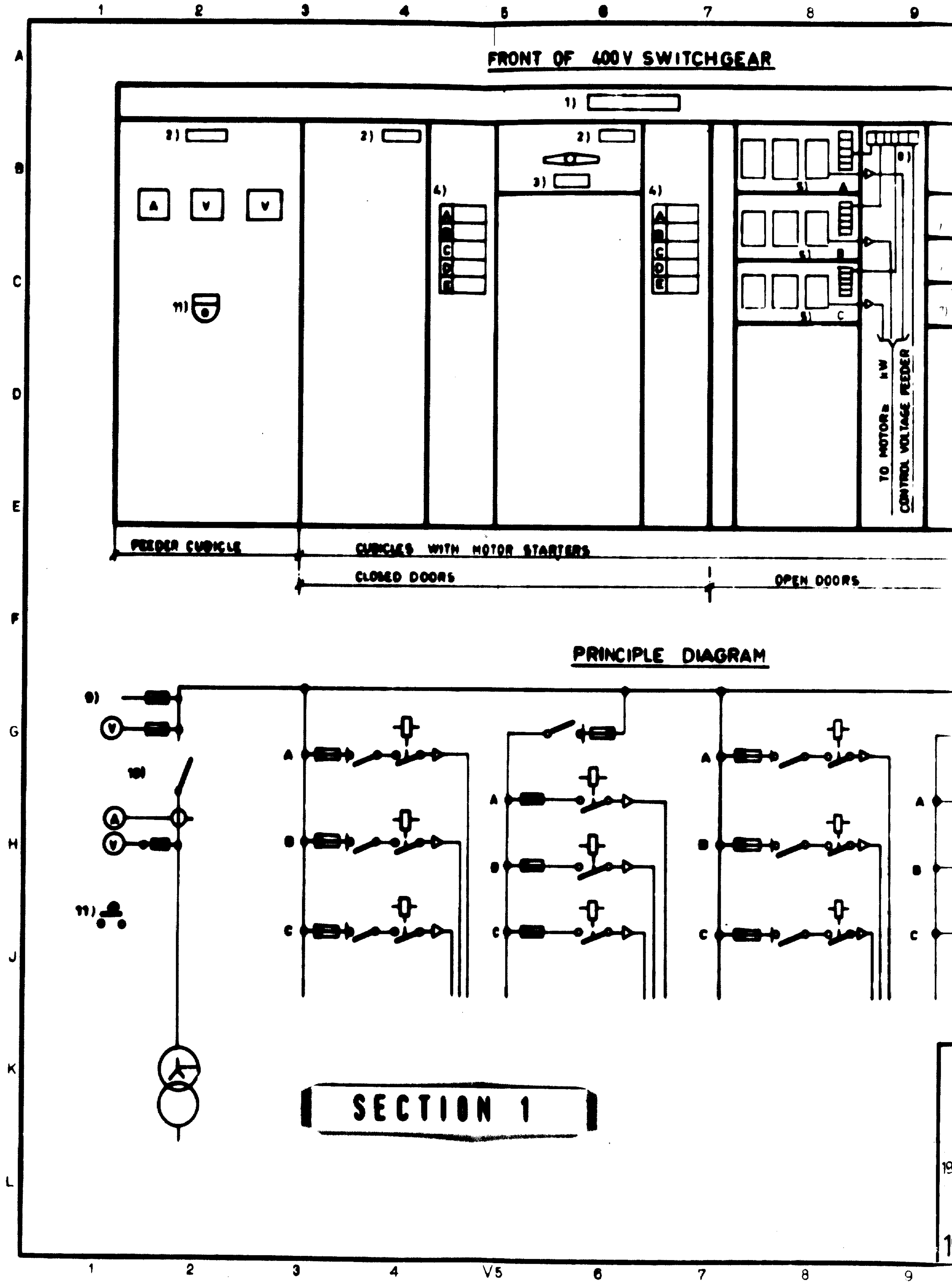
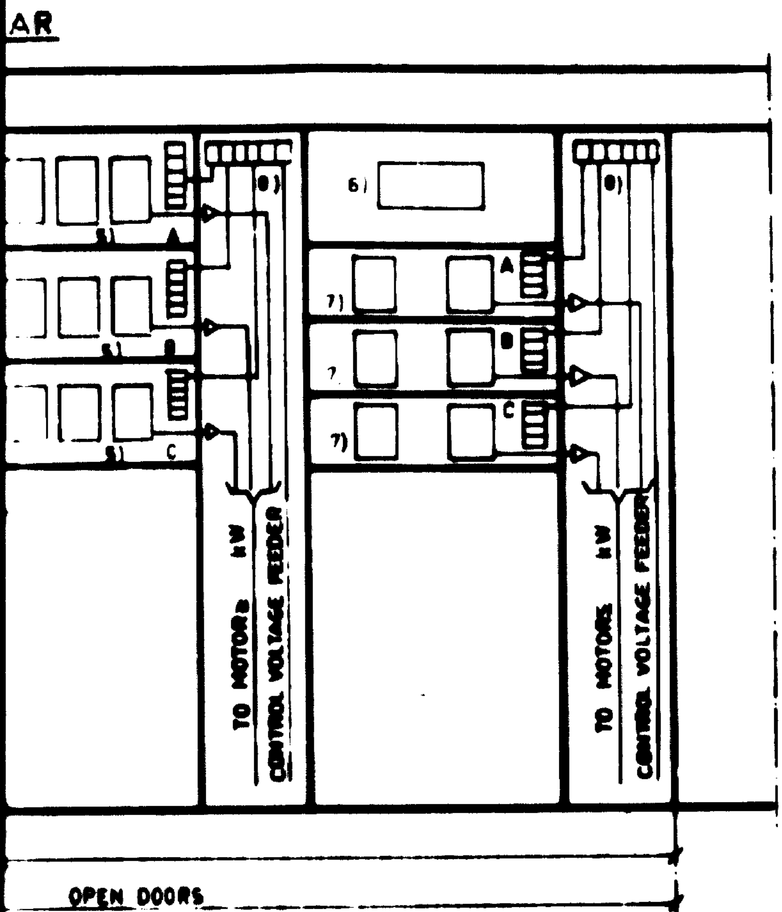
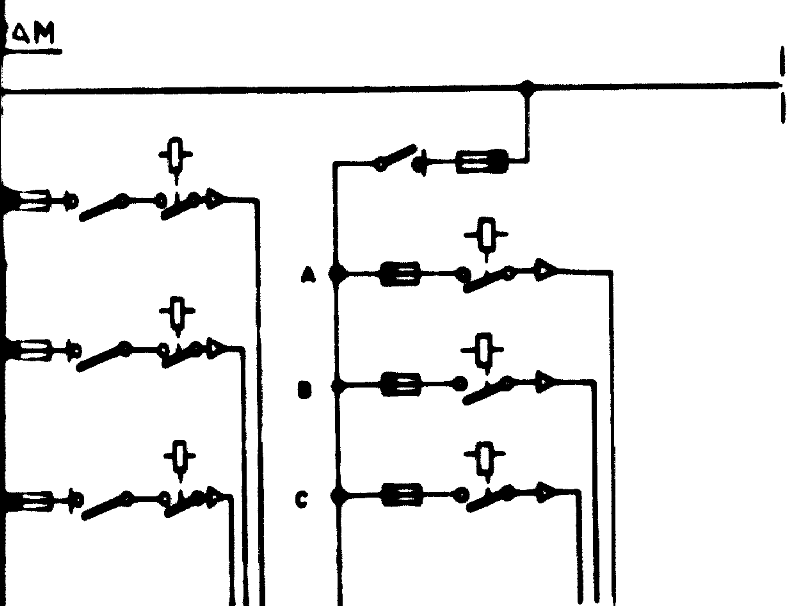

FRONT OF 400V SWITCHGEAR
FEEDER CUBICLE
CUBICLES WITH MOTOR STARTERS
CLOSED DOORS
OPEN DOORS
TO MOTORS kW
CONTROL VOLTAGE FEEDER
PRINCIPLE DIAGRAM
SECTION 1

8 9 10 11 12 13 14 15 16



Notes

1) Name-plate
2) Cubicle number-plate
3) Sign for the mains switch
4) Signs for motor starters
5) Standardised motor starter units
6) Fuses and mains switch for the cubicle
7) Standardised motor starter units
8) Control voltage terminals of isolating type with sockets for connection of test wires
9) 3-pole 25 A fuse for control voltage distribution board
10) Main circuit breaker
11) Pushbutton for tripping of high voltage circuit breaker



SECTION 2

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FABRIKA CELULOZE I VISKOZE BANJA LUKA

LOW VOLTAGE SWITCHGEAR PRINCIPLE DESIGN.

SKALA —

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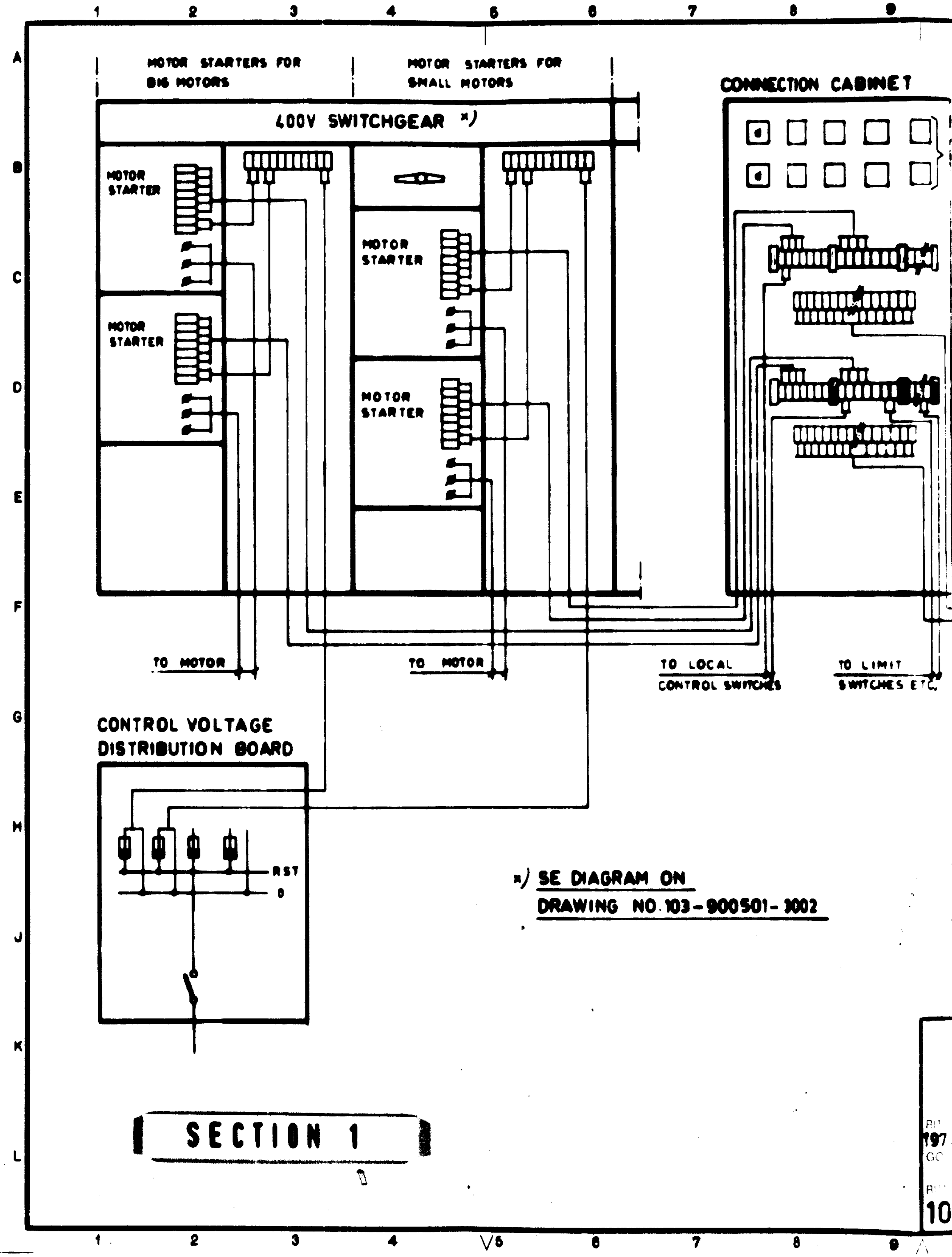

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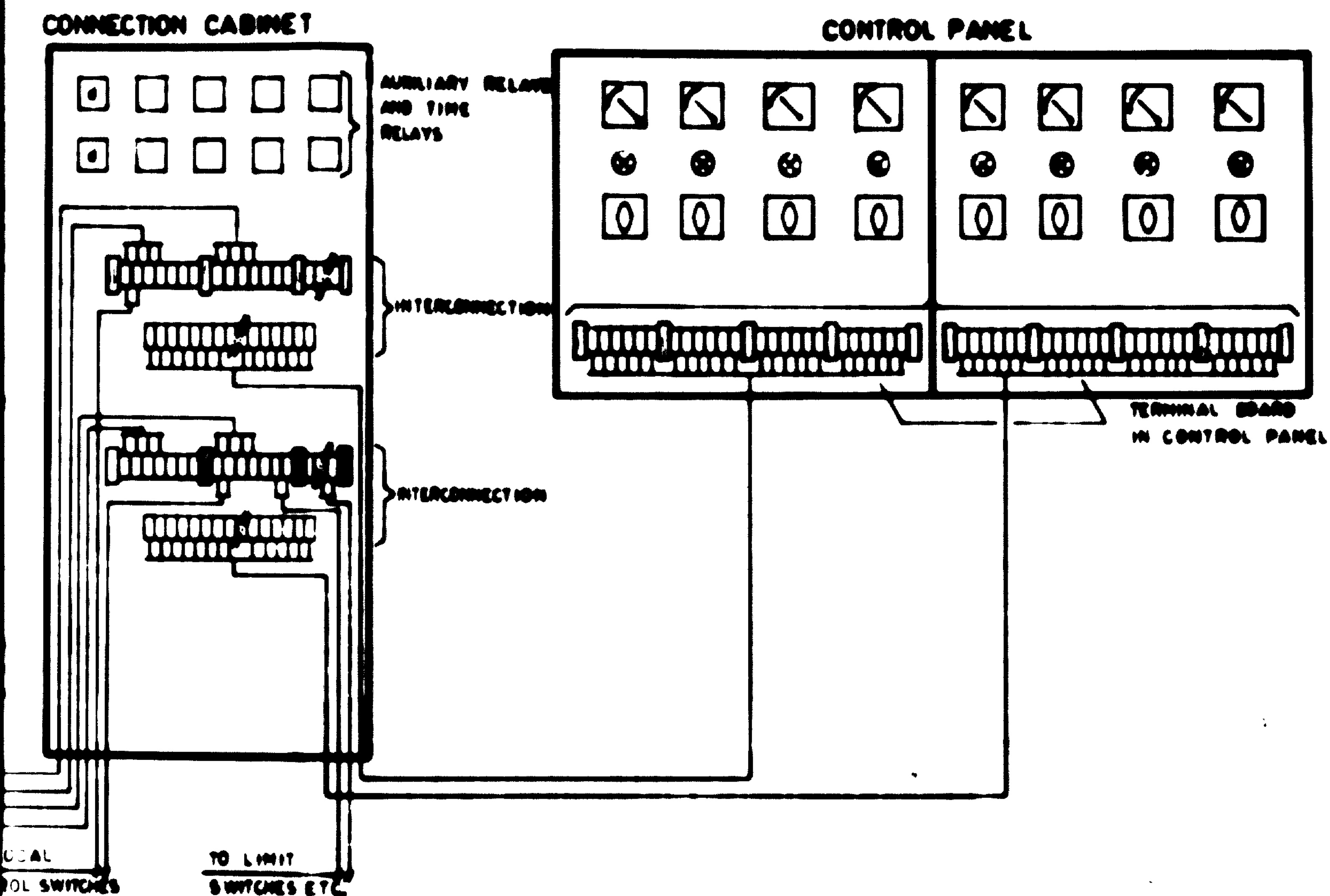
SECTION 1



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SECTION 2

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PRINCIPLE DIAGRAM FOR CONNECTION OF CONTROL CABLES

RIT	KONSTR	GRANSK	SKALA
1972-09-07	S.DAGBERG		—

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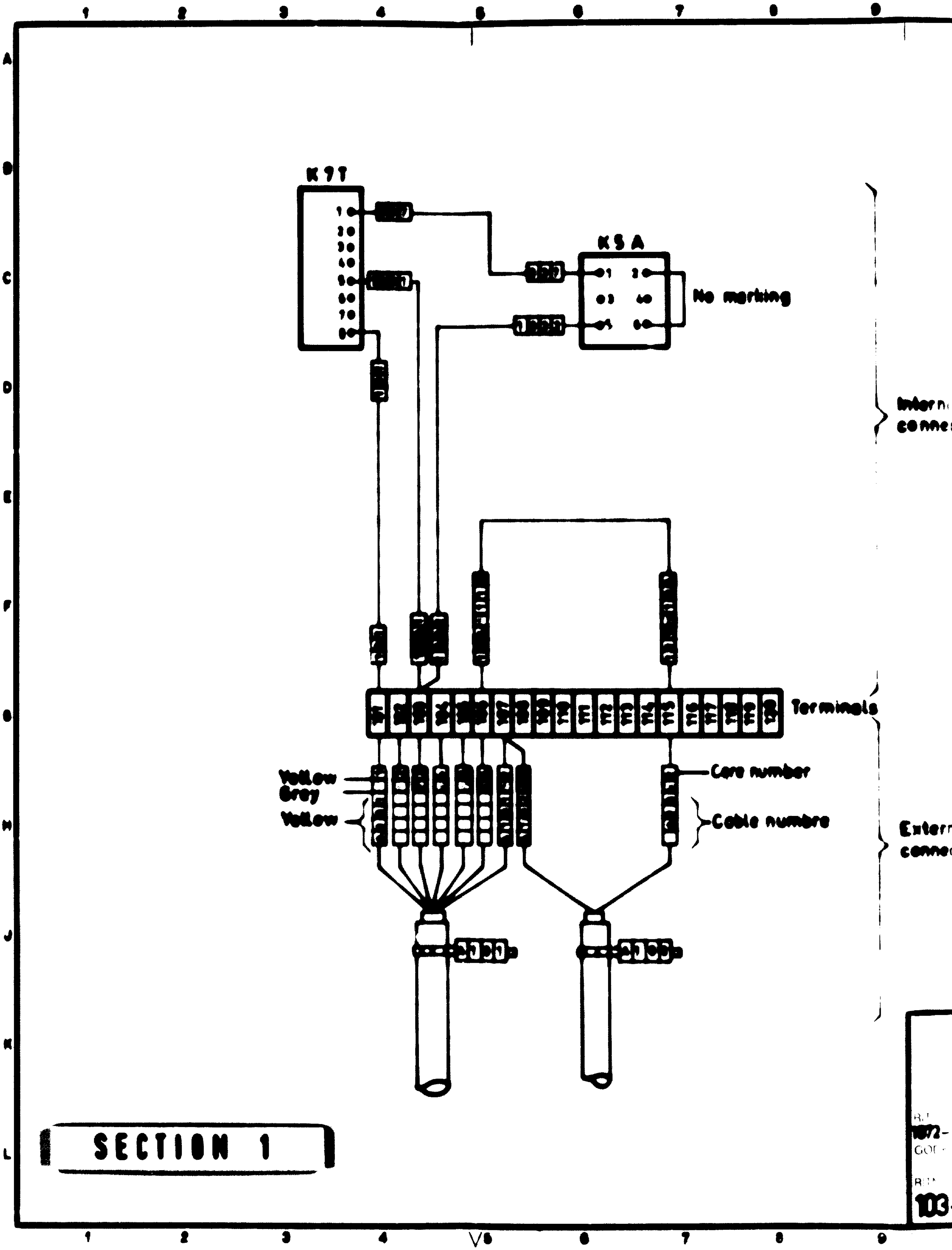
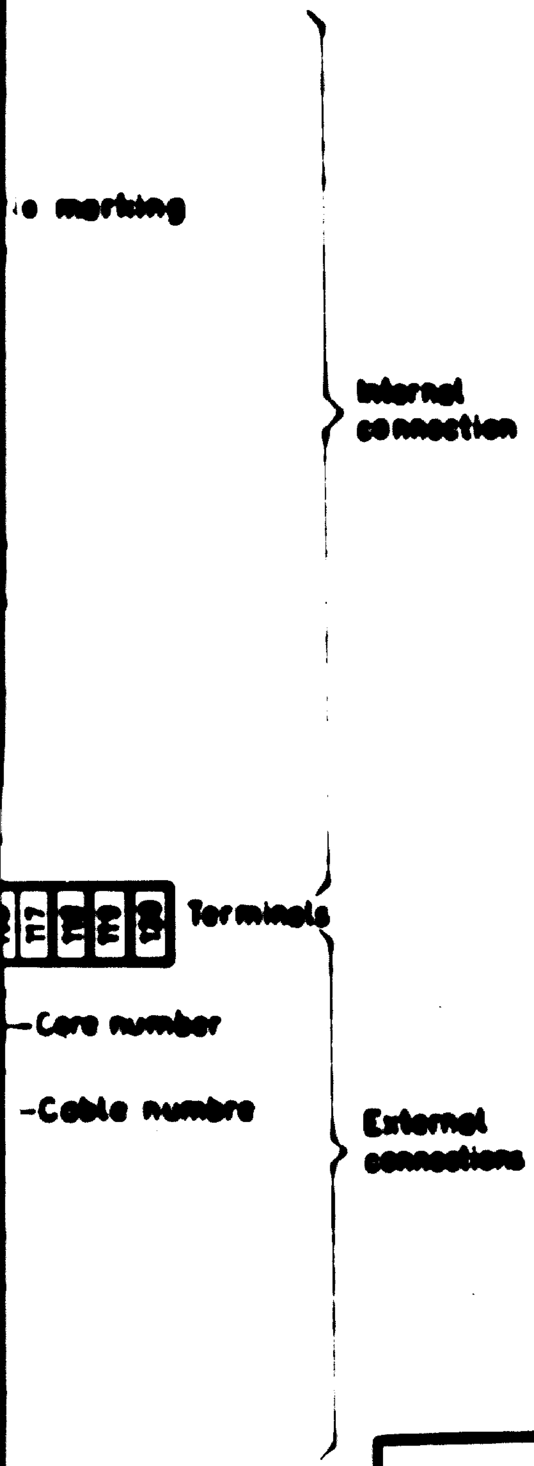


K7T
K5A
No marking
Terminals
Yellow
Grey
Yellow
Core number
Cable numbre
Intern
conne
Extern
conne

SECTION 1

VB



SECTION 2

REV	REV AVSER	SIGN	GODK	DATUM

AB ENERGIKONSULT

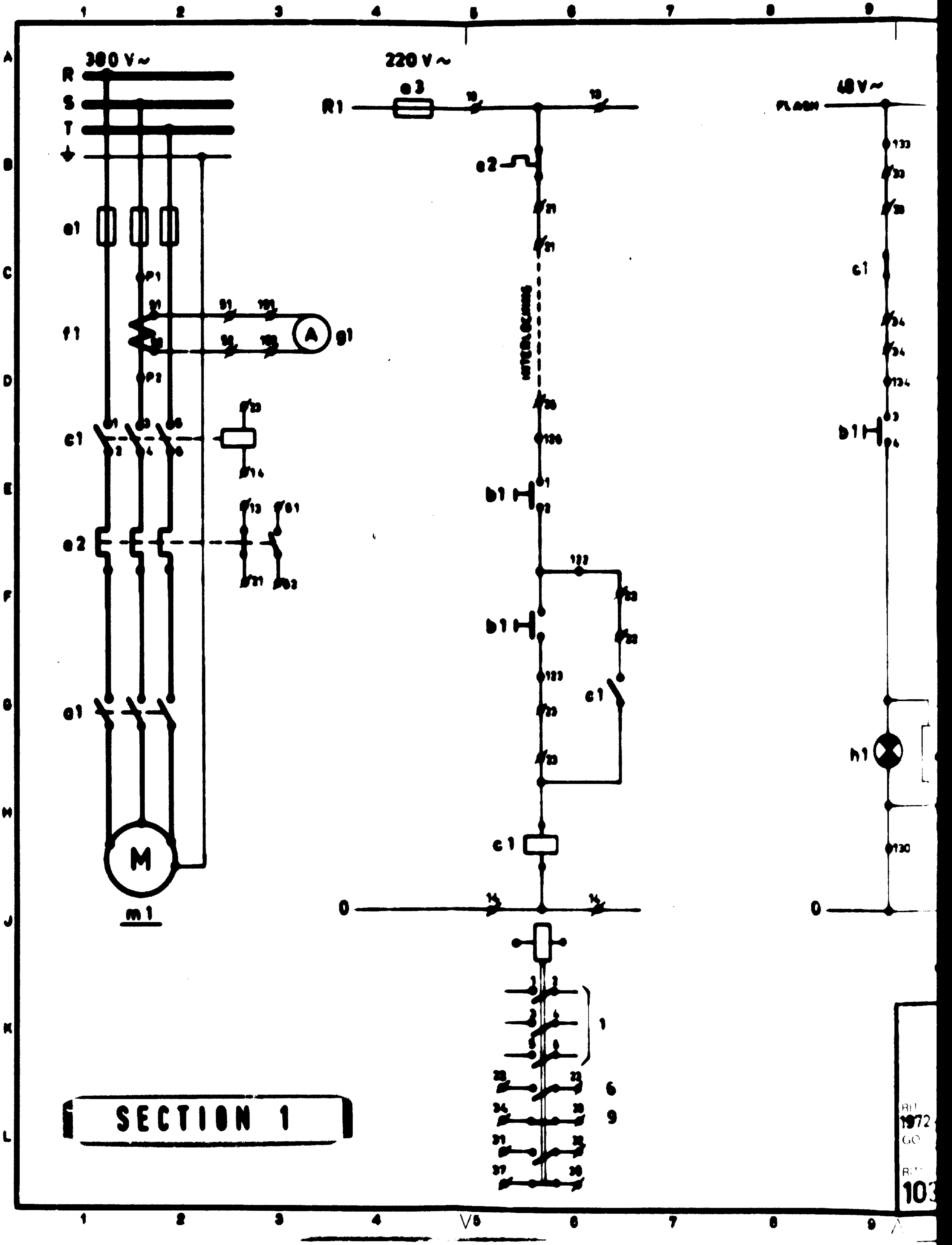
FABRIKA CELULOZE I VISKOZE
BANJA LUKA

PRINCIPLES FOR MARKING OF EXTERNAL AND INTERNAL CONNECTION

RIT	KONSTR	GRANSK
1972-09-07	S.DAGBERG	
GODK DEN		PROJ L

SKALA —

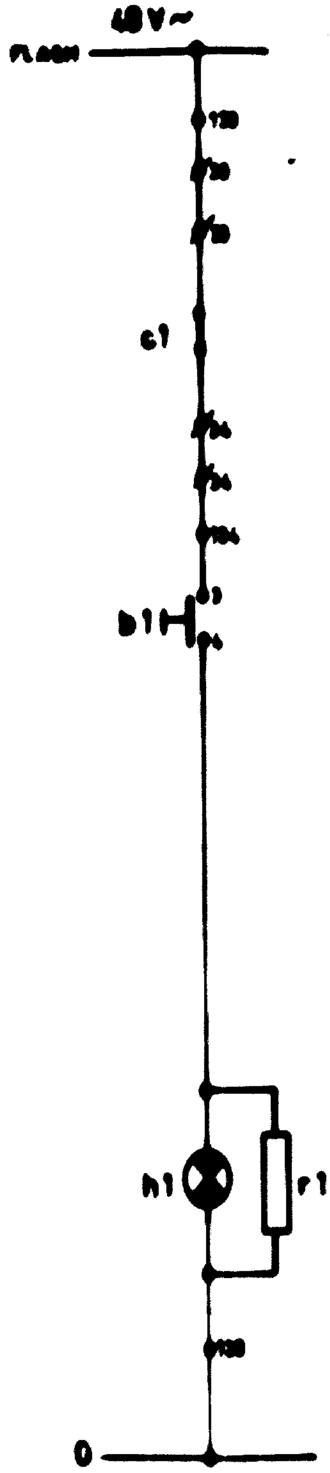
RITN NR	REV	BESTALLARENS ARB NR	BESTALLARENS RITN NR	REV
103-900501-3004				



380 V ~
R
S
T
e1
f1
g1
c1
e2
m1
M
A
220 V ~
R1
e3
e2
b1
c1
0
48 V ~
c1
b1
h1
0
1
6
9
SECTION 1

NOTATIONS ACCORDING TO DIN 40719
SYMBOLS ACCORDING TO IEC 117

e1 = SAFETY SWITCH (NEAR THE MOTOR)



b1

	1-2	3-4	5-6
STOP			
RUN	x	x	
START	x	x	x

CONTACT DIAGRAM
x = CONTACT CLOSED

SECTION 2

TERMINALS	
■	SWITCHGEAR
◢	CONNECTION CABINET
●	CONTROL PANEL

REV	REV AVSER	SIGN	GODK	DATUM

AB ENERGIKONSULT

FABRIKA CELULOZE I VISKOZE
BANJA LUKA

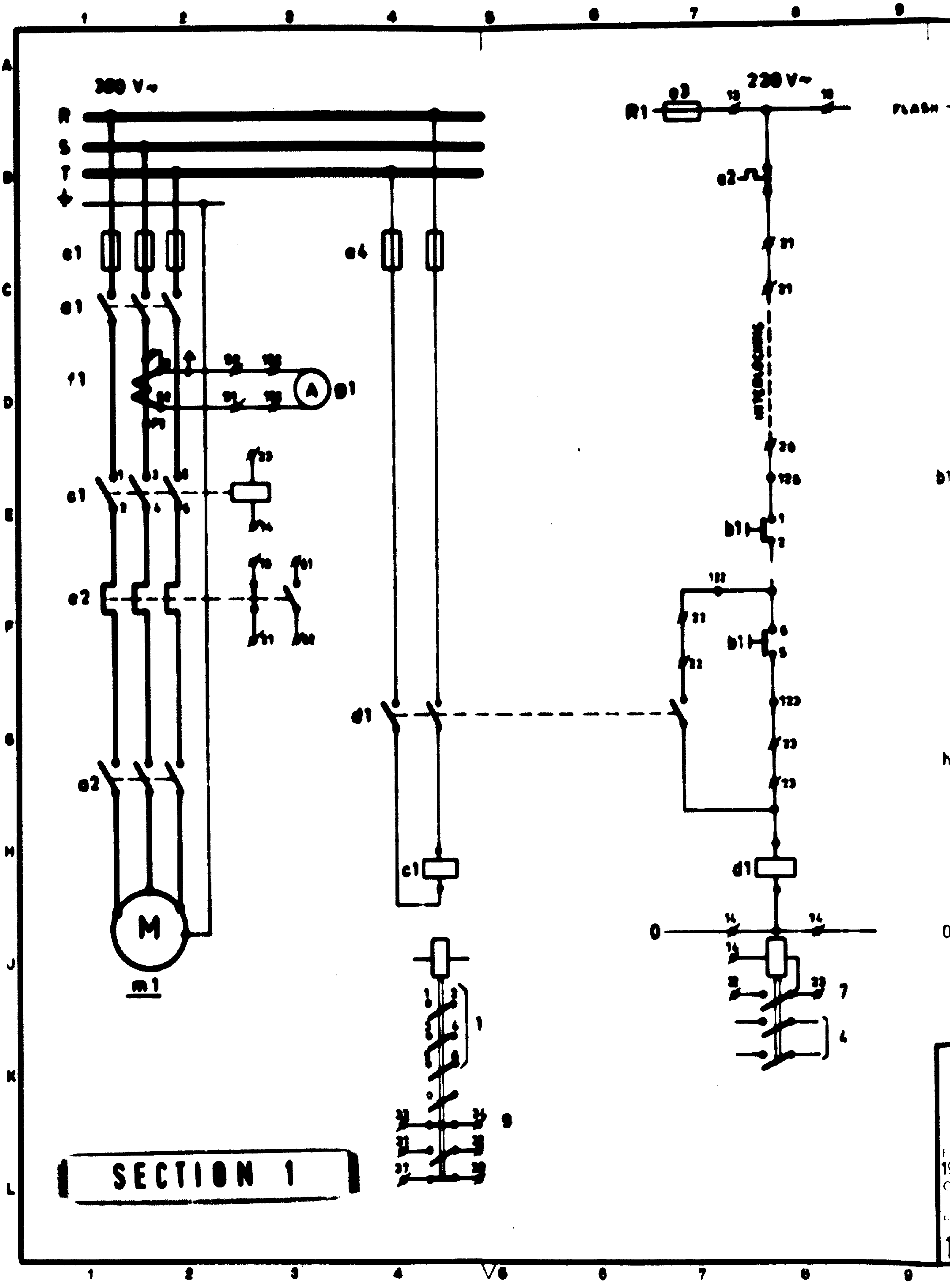
TYPE DIAGRAM.
MOTOR STARTER FOR SMALL MOTOR

RIT. 1972-09-12	KONSTR SL	GRANSK
GODK. DEN		PROJ L

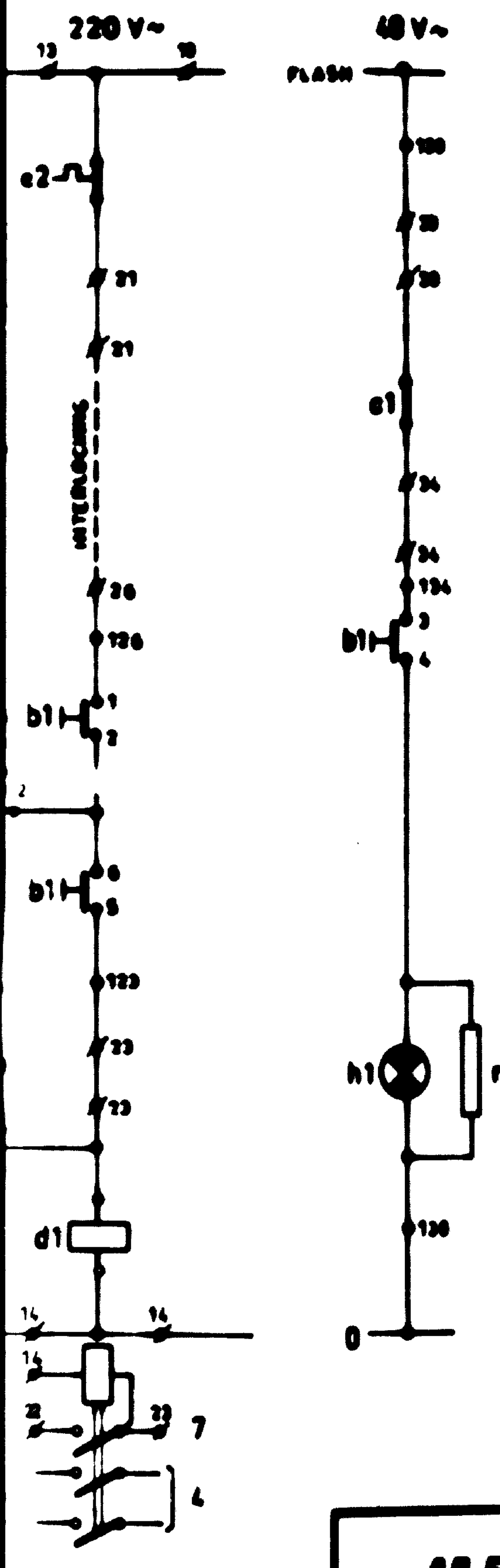
SKALA —

RITN.NR 103-900501-3005 | REV

BESTALLARENS ARB NR | BESTALLARENS RITN NR | REV



380 V~
220 V~
R
S
T
e1
e4
c1
f1
B1
A
e2
d1
M
m1
R1
e3
FLASH
b1
O
SECTION 1



NOTATIONS ACCORDING TO DIN-40719
SYMBOLS ACCORDING TO IEC-117

e1 = SWITCH
e2 = SAFETY SWITCH (NEAR THE MOTOR)

b1

	1-2	3-4	5-6
STOP			
RUN	x	x	
START	x	x	x

CONTACT DIAGRAM
x = CONTACT CLOSED

SECTION 2

TERMINALS			
∅ SWITCHGEAR			
⊘ CONNECTION CABINET			
● CONTROL PANEL			

REV.	REV. AVSER	SIGN.	GODK.	DATUM

AB ENERGIKONSULT

RIT. 1972-09-12 | KONSTR. SL. | GRANSK.
GODK. DEN | PROJ.L

RITN.NR 103-900501-3006 | REV.

FABRIKA CELULOZE I VISKOZE
BANJA LUKA

TYPE DIAGRAM. MOTOR STARTER WITH AUXILIARY RELAY FOR BIG MOTOR.

SKALA

BESTALLARENS ARB.NR | BESTALLARENS RITN.NR | REV.

	Rated power kW	Rated current I_n A	I_{st}/I_n	Starting current I_{st} A	Fuses rated current A	Fuses size	Cable Cu mm^2	Cable Al mm^2	Motor starter Rated current A	Thermal overl relay Setting range
1	0,37	1,2	4	4,3	4		2,5			
2	0,55	1,65	4,5	7,4	4		2,5			
3	0,75	2,15	5	10,3	6		2,5			
4	1,1	2,7	5,5	15	6		2,5			
5	1,5	3,6	6	22	10		2,5			
6	2,2	5,4	6,5	35	16		2,5			
7	3,0	7,0	6,5	46	20		2,5			
8	4,0	9,6	6,5	63	20		2,5			
9	5,5	12	6,5	73	25		2,5			
10	7,5	16	6,5	104	35		2,5			
11	11,0	23	6,5	150	50		4			
12	15,0	31	6,5	200	63		6			
13	18,5	37	6,5	240	80		6			
14	22	43	6,5	280	80		10			
15	30	57	6,5	370	100		16			
16	37	72	6,5	470	125		16			
17	45	87	6,5	565	160		25			
18	55	107	7	750	200		35			
19	75	142	7	1000	250		50			
20	90	170	7	1190	250		70			
21	110	212	7	1490	315		95			
22	132	254	7	1780	400		120			
23	160	320	7	2170	400		120			
24	200	375	7	2625	500		185			
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										
35										

380 V 50 Hz

1500 r/m

Starting time 5 s

VDE 0100/12.65

SECTION 1

REV	SIGN	GODK	DATUM

197

103

otor starter ated current A	Thermal overload relay Setting range	Safety switch Rated current A		Rem.

SECTION 2

AB ENERGIKONSULT

FABRIKA CELULOZE I VISKOZE

BANJA LUKA

Coordination table
motors – fuses – cables

REV.	SIGN.	GODK.	DATUM

1972.06.01 S. DAGBERG

SKALA

103-900501-3007

[illegible]

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, VIENNA

CONTRACT 71/50

Report 1 — **REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"**

Appendix 4 — Report of 22 Dec. 1972 concerning the revised design of the power station enlargement

(Ergänzung betr. die Auslegung des Kessels K5 und der Turbine T4)

Beilage 1-3

AB ENERGIKONSULT
90050
P-Beg/DS
22.12.72

FABRIKA CELULOZE I VISKOZE, BANJA LUKA

Ergänzung betreffend die Auslegung des Kessels K5 und der Turbine T4

1. Voraussetzungen

Die Grundvoraussetzungen, d.h. die Produktion, der Verbrauch von Wärme, Dampf und Elektrizität, sind dieselben wie in unseren Kalkülen vom 6.7.72 oder wie folgt:

Produktion nach Ausbau

Gebleichter Zellstoff	371 tZ/24 h	8 000 h/Jahr
Elektrolyse	8 000 t NaOH/Jahr	8 000 "
Papier	5 000 t/Jahr	7 000 "
Zellwolle	50 t/24 h	8 000 "
High Wet Modulus (HWM)	25 "	8 000 "
Zellophan	10 "	8 000 "
Polyester	?	8 000 "
Gasbeton	?	8 000 "

Wärme und Dampfverbrauch

Mittlerer Verbrauch		Wärme Gcal/h	Dampf t/h
Sommerzeit			
Dampf 12 atü		14.1	21
" 6,5 atü		26.6	42
" 3,5 " einschl. Speisewasserwärmung		109.5	225
	Total	150.2	288
Winterzeit			
Dampf 12 atü		14.1	21
" 6,5 atü		26.6	42
" 3,5 " einschl. Speisewasserwärmung		130.0	265
	Total	170.7	328
Geschätzter max. Verbrauch im Winter		181.0	347

Elektrizitätsverbrauch

Jährlicher Energieverbrauch	312 GWh/Jahr
Maximaler Leistungsbedarf	47 MW

2. Prinzipe für den Ausbau der Kraftzentrale

Um die Versorgung mit Dampf und Elektrizität für die ausgebaute Fabrik zu sichern, muss die vorhandene Kraftzentrale ausgebaut werden. Der Ausbau soll einen Kessel K5 und eine Turbine T4 umfassen.

Bei der Auslegung soll gemäss Übereinkommen in Banja Luka am 27-28.11.72 Folgendes beachtet werden.

- Der neue Kessel K5 und die neue Turbine T4 sollen im Anschluss an der vorhandenen Kraftzentrale gebaut werden.

- Für den neuen Kessel soll derselbe Genehmigungsdruck 87 atü und Dampftemperatur 515/525°C wie für die vorhandenen Kessel gewählt werden, so dass es möglich ist, der neue Kessel mit den Vorhandenen auf der Hochdruckseite anzuschliessen.

- Der neue Kessel K5 soll für Feuerung mit Kohlenstaub als Hauptbrennstoff für 100 % Belastung und mit Öl als Hilfbrennstoff für 50 % Belastung ausgelegt werden.

- Der neue Kessel soll nicht für Feuerung von Holz und Sulfitlauge ausgelegt werden.

- Die gesamte Kesselkapazität soll so ausgelegt werden, dass im Winter bei maximaler Belastung alle fünf Kessel mit Vollast im Betrieb sein müssen. Im Sommer muss eine ausreichende Dampfkapazität vorhanden sein, auch wenn einer der Kessel 1-4 ausser Betrieb ist. Mit dieser Auslegung muss man berücksichtigen, dass bei Kesselstörungen im Winter, kann volle Produktionskapazität in den Fabriken nicht erreicht werden.

- Die neue Turbine T4 soll ohne Berücksichtigung auf Turbinenreserve ausgelegt werden. Das bedeutet, dass bei Ausfall von einer Turbine, kann die volle Produktionskapazität in den Fabriken wegen Kraftmangel nicht erreicht werden. Weil die Überführungskapazität der äusseren Kraftlinie etwa 8-10 MW beträgt, kann das Risiko für Kraftmangel beseitigt werden, wenn die Kapazität der äusseren Kraftlinie erhöht wird.

- In unseren Kalkülen vom 6.7.72 war vorausgesetzt worden, dass die Turbine T1 umgebaut werden sollte, zu einer Gegendruckturbine mit Gegendruck 6,5 atü, Dampfdurchflussmenge 59.3/72.0 t/h und max. Generatorleistung 7.8 MW. Gemäss den neuen Angaben soll die Turbine T1 nicht umgebaut werden, und die Daten der Turbine bleiben wie folgt.

Dampfdurchflussmenge	70 t/h
Gegendruck	3.5 atü
Ungeregelte Entnahme	
- Druck	6.5 atü
- Max. Durchfluss	15 t/h
Max. Generatorleistung	10 MW

3. Auslegung des neuen Kessels K5 und der neuen Turbine T4

Die Auslegung geht aus den Beilagen 1-3 hervor, und wir haben gemäss Übereinkommen in Banja Luka am 27-28.11.72 die folgenden Alternativen berücksichtigt.

Alternative		1	2	3
Kessel K5 Max. Kapazität	t/h	140	180	180
Turbine T4 Max. Generatorleistung	MW	-	12	23

Betreffend die Auslegung der Turbine kann folgendes bemerkt werden.

- In Alternative 1 ist die Kesselkapazität unzureichend für eine neue Turbine.

- In Alternative 2 wird die neue Turbine im Anschluss zu dem neuen Kessel installiert, in einer Verlängerung des Turbinenhauses.

- In Alternative 3 wird die Turbine T1 abgeschafft, und am freiwerdenden Platz im Turbinenhaus wird die Turbine T4 installiert.

- Aus den Dampfbilanzen geht hervor, dass die neue Turbine als eine Gegendruckturbine ohne Kondensationsteil ausgelegt werden soll.

Auslegung vom Kessel K5

Alternative		1	2 und 3
Genehmigungsdruck	atü	87	87
Dampftemperatur	°C	515/525	515/525
Speisewassertemperatur	°C	143	143
Dampferzeugung			
- Nominelle Dauerleistung	t/h	100	140
- Max. Dauerleistung	"	120	160
- Spitzenleistung	"	140	180
Brennstoff		Kohlenstaub 100 % Belastung Öl 50 % Belastung	

Auslegung von Turbine T4

Alternative		2	3
Admissionsdampf			
- Druck	atü	71	71
- Temperatur	°C	515	515
- Dampfdurchfluss	t/h	80	150
- Gegendruck	atü	3.5	3.5
- Entnahme 12 atü	max t/h	-	30
- Entnahme 6,5 atü	max t/h	15	15
- Max. Generatorleistung	MW	12	23
- Generatorspannung	kV	10	10

4. Versorgung von Dampf und elektrischer Kraft

Versorgung von Dampf

Bei den Kalkülen sind als sichere Dampfleistung für die alten Kessel K1-4 mit der nominellen Dampfleistung und für den neuen Kessel K5 mit der max. Dauerleistung gerechnet.

Alternative	1 t/h	2 t/h	3 t/h
Kessel K1	50	50	50
K2	50	50	50
K3	50	50	50
K4	50	50	50
K5	120	160	160
Total	320	360	360
Nötiger Hochdruckdampfbedarf im Sommer. (Siehe Anl. 1-3)	284	302	302
Differenz = Kesselreserve im Sommer	36	58	58
Nötiger Hochdruckdampfbedarf im Winter	306	339	339
Differenz = Kesselreserve im Winter	14	21	21

Versorgung von elektrischer Kraft

Alternative	1	2	3
Turbinenleistung (s. Anl.1-3)	MW	MW	MW
Sommerzeit			
Turbine T1 10 MW	10,1	10,1	-
T2 16 "	16,0	16,0	16,0
T3 16 "	16,0	16,0	16,0
T4 12 bzw. 23 MW	-	4,6	13,0
Total	42,1	44,7	45,0
Winterzeit			
Turbine T1 10 MW	10,1	10,1	-
T2 16 "	16,0	16,0	16,0
T3 16 "	16,0	16,0	16,0
T4 12 bzw. 23 MW	-	11,0	19,6
Total	42,1	53,1	51,6

Wenn man Störungen in der Produktion in der Fabrik wegen Kraftmangel vermeiden will, muss die äussere Kraftlinie genügend Kapazität haben. Wir berechnen die nötige Überführungskapazität der äusserenKraftlinie mit den folgenden Voraussetzungen.

- Die grösste Tubine ist ausser Betrieb gesetzt.

- Die Leistung der übrigen Turbinen ist 90 % der maximalen Leistung.

Die Berechnungen sind wie folgt:

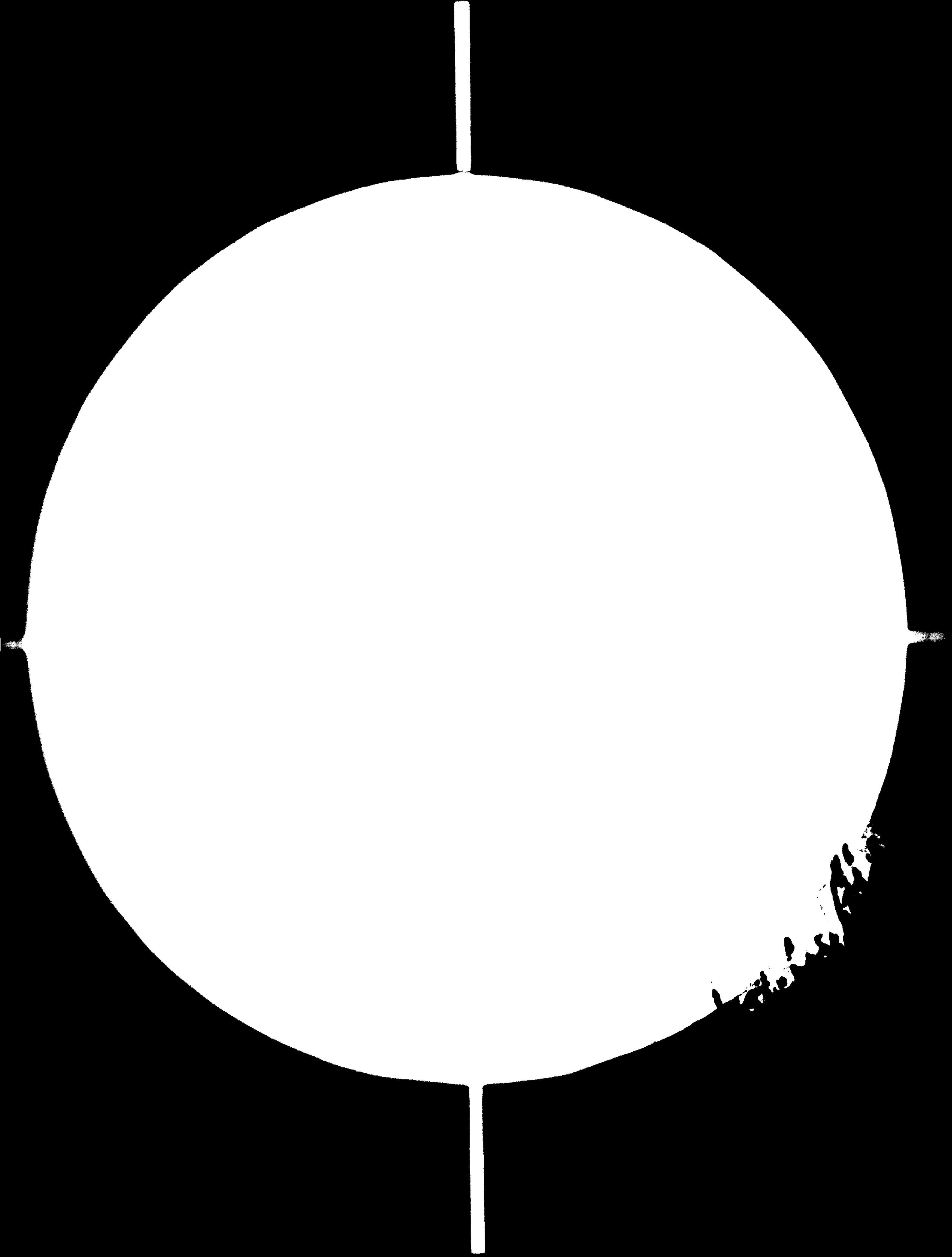
Alternative	1	2	3
	MW	MW	MW
Max. Bedarf	47	47	47
Leistung der Turbinen, wenn die grösste Turbine ausser Betrieb ist	23	34	29
Differenz = nötige Kapazität der äusseren Kraftlinie	24	13	18

Stockholm, 22.12.1972.
AB ENERGIKONSULT
Grels Berg

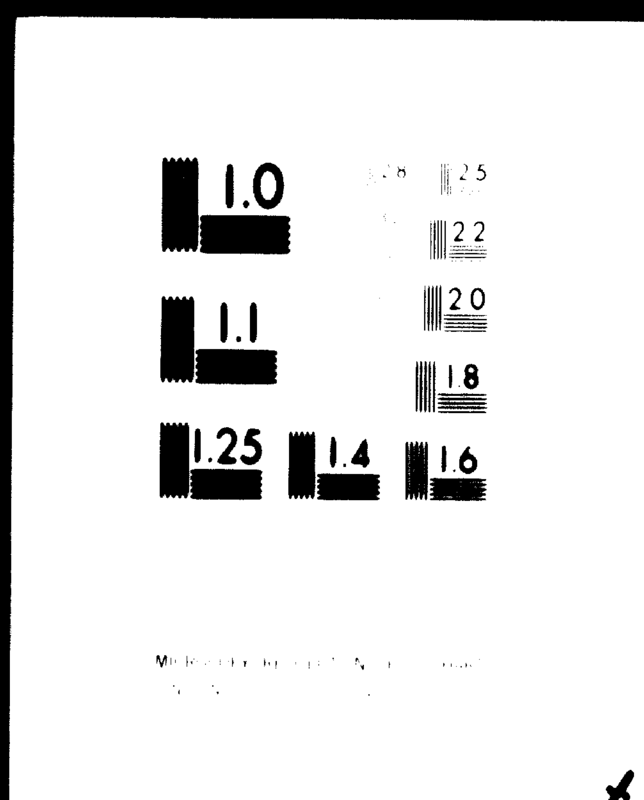
Anl. Dampf- und Kraftmengen voller Kondensationsbetrieb
Alt. 1 101-500505-4006
Alt. 2 101-500505-3001
Alt. 3 101-500505-4007

C-932

82.11.04



2 OF 2



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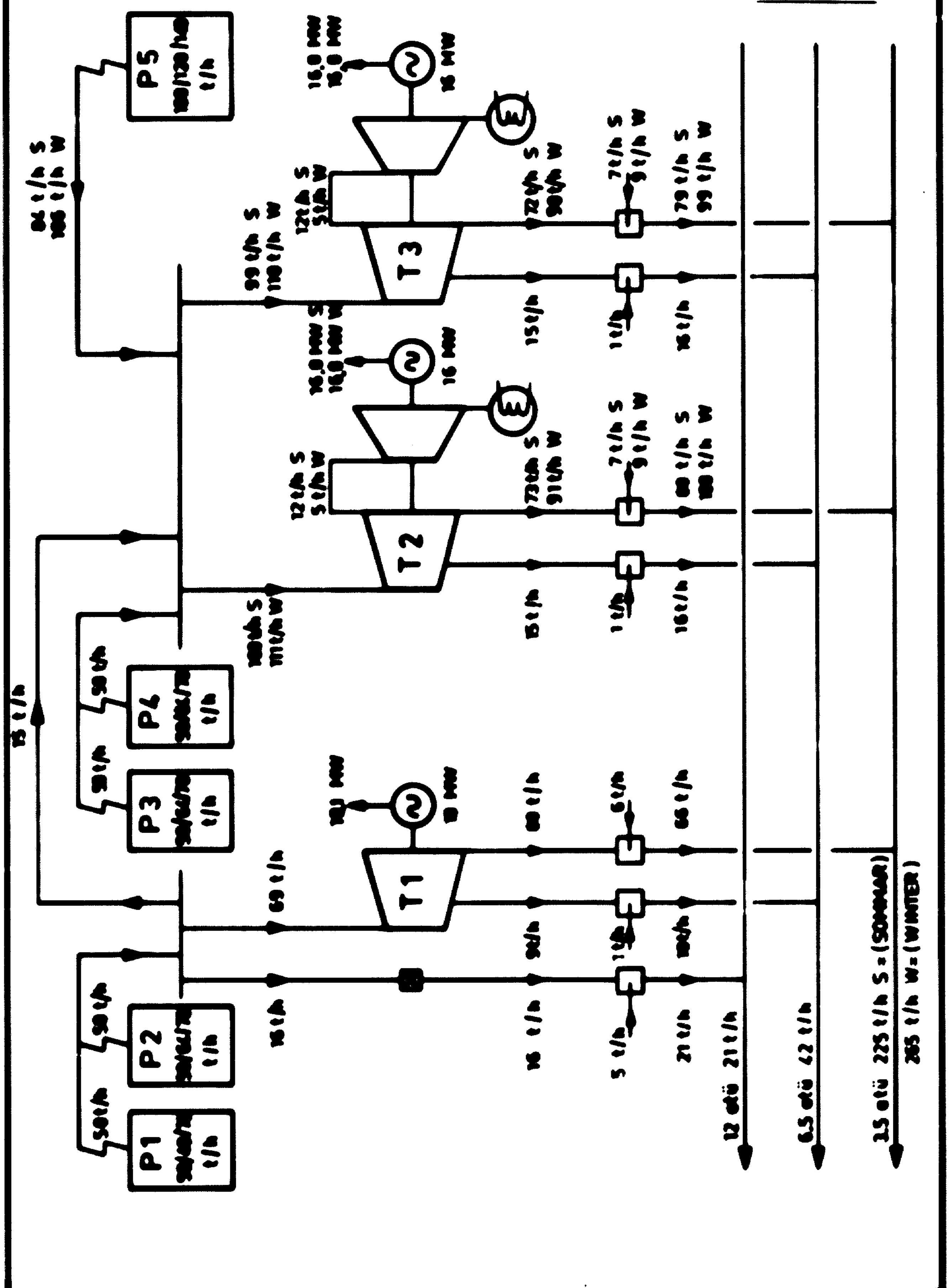
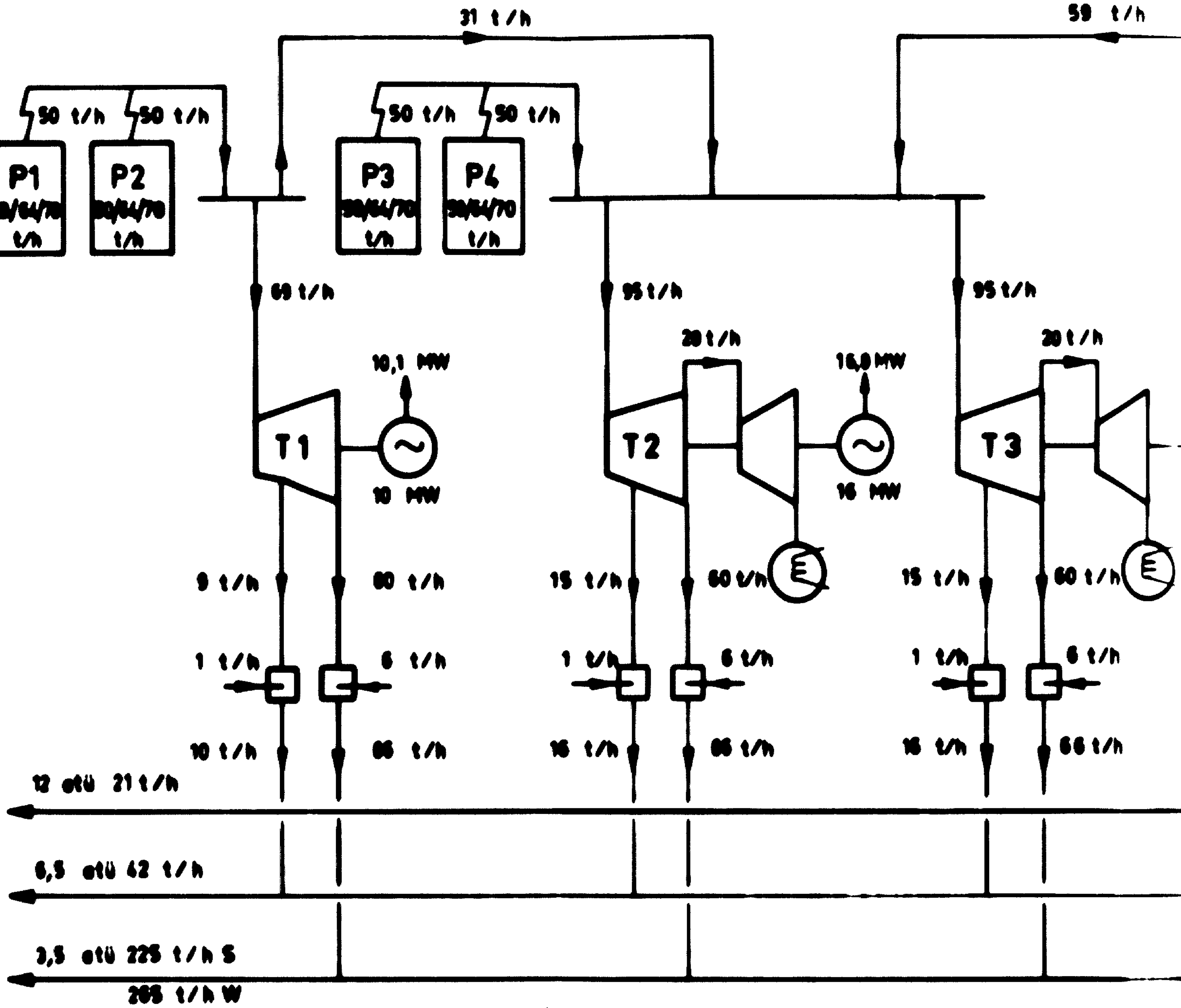


ENERGIKONSULT	
MD	STHLM 22.12.72
Check	Arb. nr
Ritn nr 101-500305-4006	

FABRIKA CELULOZE I VISKOZE, BANJA LUKA

DAMPF- und KRAFTMENGEN VOLLER KONDENSBETRIEB MIT T2 und T3



SECTION 1

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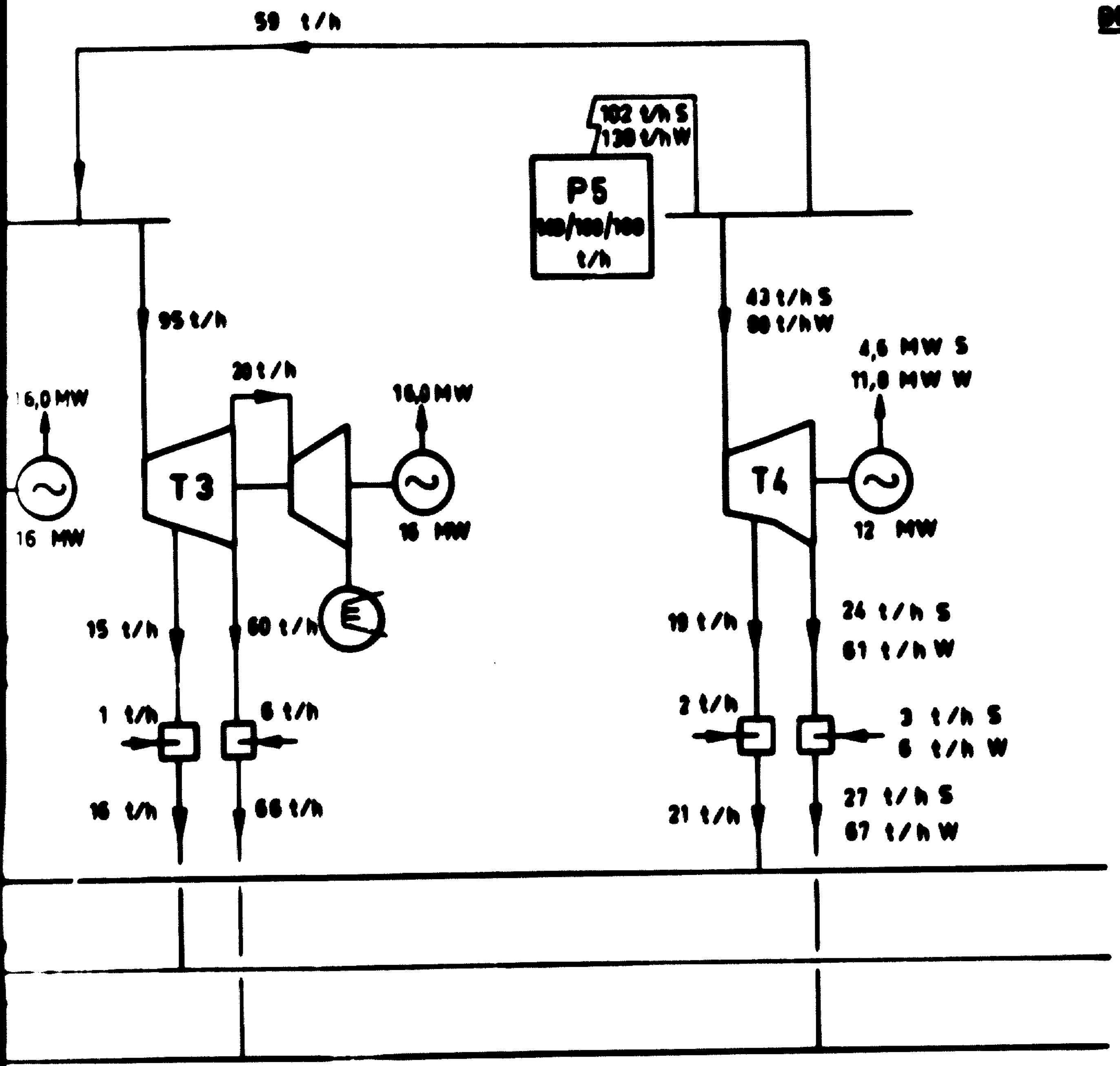
BEILAGE 2



SECTION 2

REV.	REV. AVSER	SIGN.	GODK.	DATUM

AB ENERGIKONSULT

FABRIKA CELULOZE I VISKOZE,
BANJA LUKA

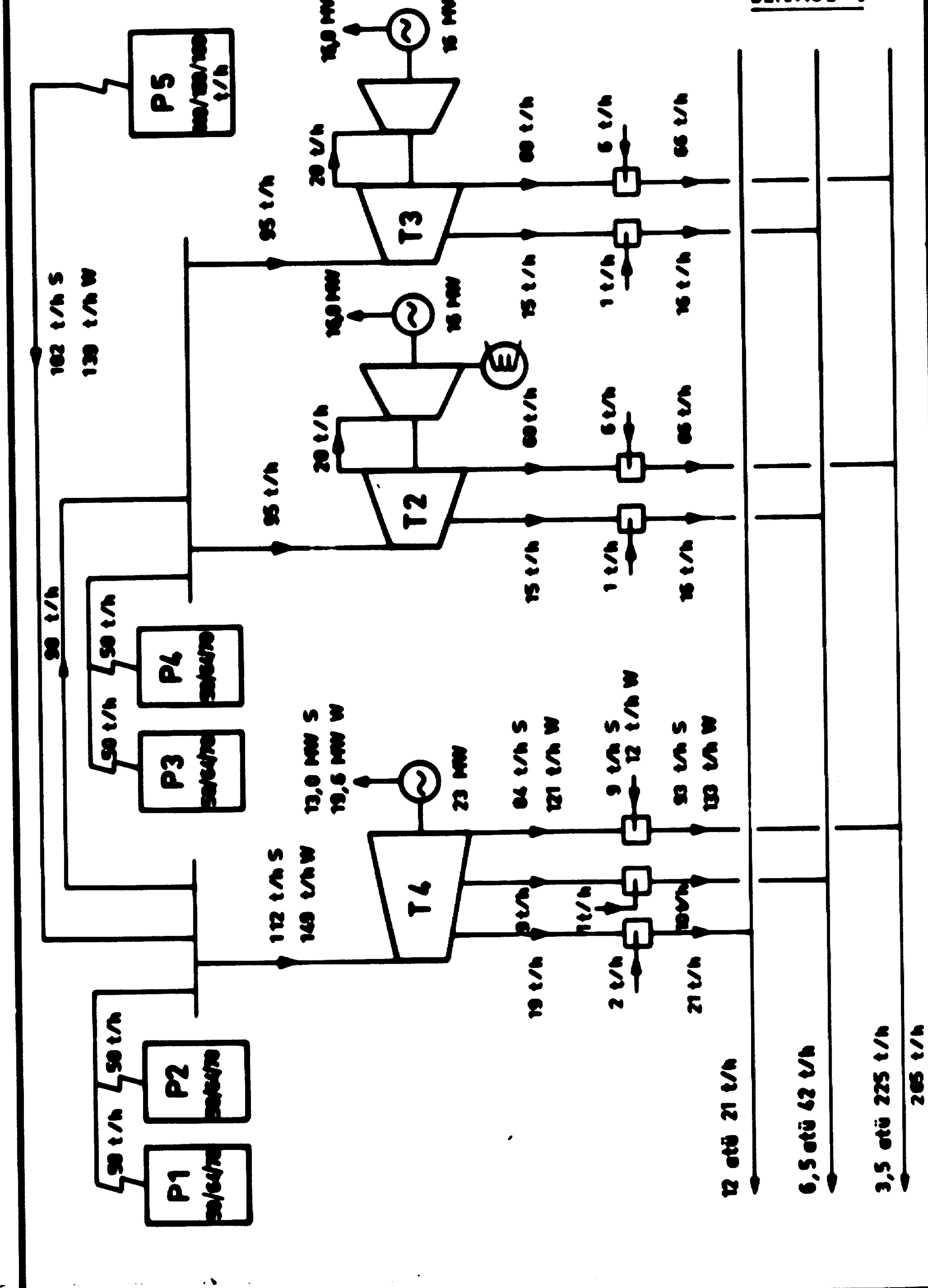
DAMPF- und KRAFTMENGEN VOLLER KONDENSBETRIEB MIT T2 und T3

RIT. MW	KONSTR.	GRANSK.
GODK. DEN 22.12.72		PROJ.L
RITN NR 101-500505-3001		REV.

SKALA

BESTÄLLARENS ARB NR	BESTÄLLARENS RITN NR	REV.

BEILAGE 3



ENERGIKONSULT	FABRIKA CELULOZE I VISKOZE, BANJA LUKA
Rit. MD — STHLM d. 22/12. 72	DAMPF- und KRAFTMENGEN VOLLER KONDENSBETRIEB
Check — Arb. nr	MIT T2 und T3
AF:s Ritn nr 101-500505-4007	

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, VIENNA

CONTRACT 71/50

Report 1 REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"

Appendix 5 Letter to Banja Luka of 29 Jan. 1973
2 enclosures.
For the specifications mentioned in the letter, see Appendix 6 und Appendix 7

HEAD OFFICE
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Telephone: 08/23 46 00
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AB ENERGIKONSULT

SUBSIDIARY OF ÅNGPANNEFÖRENINGEN (Swedish Steam Users' Association)

Fabrika celuloze i viskoze
BANJA LUKA
Jugoslavien

Please refer to
Ing. Grels Berg

Your ref.	Your letter	Our ref.	Stockholm,
Dr. Midhat Kurbegovic		90051 P-Beg/DS	29.1.1973.

Gemäss Auftrag haben wir die Spezifikationen für den neuen Kessel K5 und die neue Turbine T4 gemacht, und zwar auf englisch. Ihrem Wunsch gemäss haben wir die Spezifikationen für zwei Alternativen gemacht, und der Auslegung gemäss unserer "Ergänzung betreffend die Auslegung des Kessels K5 und der Turbine T4" vom 22.12.72 gefolgt. Die Alternativen sind wie folgt:

Kessel K5

Alternative	1	140 t/h
"	2	180 "

Turbine T4

Alternative	2	12 MW
"	3	23 "

Ihrem Wunsch gemäss haben wir die Spezifikationen so gemacht, dass die Lieferung eine komplette Anlage umfasst, mit Gebäude, Rohrleitungen, Instrumentierung, elektrischer Ausrüstung usw. Für die Rohrleitungen haben wir so viel wie möglich in den Spezifikationen mitgenommen, leider könnten wir nicht den kompletten Rohrleitungsausbau der Kraftzentrale in den Spezifikationen mitnehmen, weil das Rohrleitungsschema für den Ausbau noch nicht ausgeführt ist. Die Ursache dafür, dass wir dieses Schema noch nicht ausgeführt haben, ist, dass die zwei Alternativen für Kessel K5 und für Turbine T4, drei Alternativen für den Rohrleitungsausbau geben. Wir haben es nicht als richtig gefunden, unnötige Arbeit zu tun, um drei alternative Rohrleitungsschemata auszuführen, und von den Lieferanten Angebote für drei verschiedene Alternativen einzufordern.

Wenn Sie den Beschluss gemacht haben, welche Alternative von Kessel und Turbine gewählt werden soll, kann das Rohrleitungsschema ausgeführt werden, und die kompletten Rohrleitungsspezifikationen können dann ausgeführt werden.

Wir haben geprüft und gefunden, dass die vorhandene Wasserbereitungsanlage, Speisewasserbehälter und Speisepumpen ausreichend sind, auch für den Kessel 5.

Die vorhandenen Dampfreduzierventile und Dampfkühler müssen mit neuen Einheiten komplettiert werden. Die Auslegung der Ventile und Kühler kann erst dann gemacht werden, wenn das Rohrleitungsschema festgelegt ist.

Bei Ausführung der Spezifikationen haben wir gefunden, dass einige Unterlagen fehlten, und wir waren deshalb gezwungen, einige Schätzungen zu machen. Wir bitten Sie die Spezifikationen zu kontrollieren, so dass Sie davon überzeugt sind, dass die Spezifikationen Ihre Wünsche auffüllen. Wenn dies nicht der Fall ist, müsste man Berichtigungen machen, bevor die Spezifikationen an die Lieferanten ausgeschickt werden.

Ein sehr wichtiger Punkt für die Auslegung des Kessels ist die Qualität der Kohle, die zur Verfügung steht. Von Ihren Kohlenanalysen haben wir die folgenden Werte genommen, und in die Kesselspezifikation eingetragen.

Unterer Heizwert	2 700 kcal/kg
Wassergehalt	36 %
Aschegehalt	16 %
Flüchtige Bestandteile	27 %
Mahlbarkeit	40 Hardgrove
Stückgrösse	0-80 mm
Sinteranfang der Asche	900 °C
Schmelzpunkt der Asche	1 300 °C

Wir bitten Sie zu kontrollieren, dass diese Werte richtig sind.

Betreffend die Liefergrenzen gibt es Lücken in der elektrischen Ausrüstung zwischen Generator und Transformator, und zwischen Transformator und Schaltanlagen. Die Lücken beruhen darauf, dass Sie noch nicht Stellung genommen haben, betreffend die Ausführung der 20 kV Verteilung, die gleichzeitig mit dem Ausbau der Kraftzentrale angeschafft werden muss.

Wir haben auch Verzeichnisse über Lieferanten von Kesseln und Turbinen gemacht, die als Lieferanten für diese Lieferungen passend sind. Wie wir übereingekommen haben, sollen Sie die Übersendung der Spezifikationen an den Lieferanten besorgen.

Wenn Sie mehrere Exemplare von den Spezifikationen brauchen, teilen Sie uns bitte davon mit, und wir werden Ihnen solche zugehen lassen.

In den Spezifikationen haben wir Ihre Zeichnungen K-01.036.00 und K-01.036.14 als Anlagen mitgenommen. Die Zeichnungen zeigen die Aufstellung der vorhandenen Kraftzentrale. Wir bitten Sie diese Zeichnungen den Spezifikationen beizufügen, bevor Sie die Spezifikationen an den Lieferanten übersenden.

Mit freundlichen Grüssen

AB ENERGIKONSULT

Grels Berg

Grels Berg

Anlagen:

Verzeichnis von Kessellieferanten
Verzeichnis von Turbinenlieferanten
Specification for the delivery of a steam generator 140 resp. 180 t steam/h
Specification for the delivery of a back pressure steam turbine of 12 resp. 23 MW

FABRIKA CELULOZE I VISKOZE, BANJA LUKA, JUGOSLAWIEN

Verzeichnis von Kessellieferanten

Name und Adresse	Vertreter in Schweden
AB Svenska Maskinverken S-175 02 JÄRFÄLLA 2 Schweden	
Götaverkens Ångtekniska AB Fack 402 70 GÖTEBORG 8 Schweden	
OY Tampella AB Verkstaden, TAMMERFORS Finnland	Tampella Trading AB Box 81 163 21 SPÅNGA Schweden
A Ahlström OY Verkstaden WARKAUS Finnland	A Ahlströms Svenska Industrier AB Box 6048 600 06 NORRKÖPING Schweden
A/S Burmeister & Wain's Motor- och Maskinfabrik af 1971 DK-1449 KOPENHAGEN Dänemark	
Vereinigte Kesselwerke AB Werdener Strasse 3 DÜSSELDORF Deutschland (West)	Richard Nilsson AB Becksjudarvägen 35 131 00 NACKA 1 Schweden
Deutsche Babcock & Wilcox AG D-42 OBERHAUSEN Deutschland (West)	- " -
L & C Steinmüller GmbH 527 GUMMERSBACH 1 Postfach 1949/1960 Deutschland (West)	C A Mörck AB Betzensgatan 6 414 55 GÖTEBORG Schweden
M.A.N. AG 8500 NÜRNBERG Abholfach Deutschland (West)	Hammar & Co AB Strandvägen 5 B 114 51 STOCKHOLM Schweden
Mitsubischi International GmbH 4 DÜSSELDORF Ludwig Zimmermannstrasse 1 Detuschland (West)	

V/O Energomachexport
Mosfilmovskaja 35
MOSKVA V-330
USSR

Skodaexport,
Aussenhandelsunternehmen
Vaclavske Nam 56
PRAG
Tschechoslowakei

Technocommerz GmbH
Deutsche Demokratische Republik
DDR 108 BERLIN

Elektrim
15/17 Czackiego Strasse
WARSCHAU
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mbH
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Swedish Import Contact AB
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Artillerigatan 16
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I L Ståhlberg
576 00 SÄVSJÖ

FABRIKA CELULOZE I VISKOZE, BANJA LUKA, JUGOSLAWIEN

Verzeichnis von Turbinenlieferanten

Name und Adresse	Vertreter in Schweden
Stal-Laval Turbin AB 612 20 FINSPÅNG Schweden	
Kraftwerk Union AB ERLANGEN Deutschland (West)	Siemens AB Fack 104 35 STOCKHOLM 23
AEG-Kanis Turbinenfabrik GmbH NÜRNBERG Deutschland (West)	Elektriska AB AEG 171 91 SOLNA
Brown, Boveri & Co CH-5401 BADEN Schweiz	Brown Boveri Svenska AB Midskogsgränd 5 100 54 STOCKHOLM 39
Borsig GmbH 1 BERLIN 27 Postfach Berlin(West)	
M.A.N. AG 8500 NÜRNBERG Abholfach Deutschland (West)	Hammar & Co AB Strandvägen 5 B 114 51 STOCKHOLM Schweden
Creusot-Loire (Schneider) LE CREUSOT Frankreich	AB Bonthron & Ewing Box 632 101 28 STOCKHOLM 1 Schweden
Soget (Rateau, Alsthom) 141 Rue Rateau 93 LA COURNEUVE Frankreich	AB Sveadiesel Box 3004 S-171 03 SOLNA 3
V/O Energomachexport Mosfilmovskaja 35 MOSKVA V-330 USSR	
Skodaexport Aussenhandelsunternehmen Vaclavske Nam 56 PRAG Tschechoslowakei	

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World Trade Center Bldg
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2-6 2-Chome, Ohtemachi Chiyoda
TOKYO 100
Japan

Mitsubishi International GmbH
4 DÜSSELDORF
Ludwig-Zimmermann-Strasse 1
Deutschland (West)

Jugoturbina
KARLOVAC
Jugoslawien

AB [illegible]

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, VIENNA

CONTRACT 71/50

Report 1 — **REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"**

Appendix 6 — Specification for the delivery of a steam generator 140 resp. 180 t steam/h

Drawings not included

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FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA

SPECIFICATION FOR THE DELIVERY OF A
STEAM GENERATOR 140 RESP. 100 T STEAM/H

INDEX

Appendices

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FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA

SPECIFICATION FOR THE DELIVERY OF A

STEAM GENERATOR 140 RESP. 180 T STEAM/H

1. CONDITIONS OF OPERATION

1.1 The existing industrial steam power station in Banja Luka provides steam and electric power to a combinate consisting of factories for the production of dissolving pulp (Ca basis), paper, rayon, high wet modulus fibers, cellophan, NaCl electrolysis. The plans for the nearest future are to connect to the power station new factories for the production of light concrete and polyester, which factories already are under construction, and possibly expand the existing pulp mill.

1.2 The existing steam power station consists of four boilers with a max steam generating capacity of 70 t/h each and of three steam turbines. The installed steam generating capacity will not be sufficient for the future need and therefore the steam power station will be enlarged with a new boiler according to this specification.

1.3 The new boiler shall be made for the same steam conditions as the actual boilers, in order to make possible a parallel run of all the boilers installed.

1.4 The new boiler shall be installed out of doors and placed in line with the existing boilers and beside the existing boiler No 4.

1.5 The steam load of the new boiler will normally be steady with slow variations between 40 - 100 % of full load.

1,6 The operating time will be 7 000 - 8 000 h/year. The new boiler will be taken out of operation for inspection and service only once or twice a year. The reliability is therefore of utmost importance.

1.7 The main fuel shall be pulverized coal. As auxiliary fuel fuel oil will be used.

1.8 The boiler shall be operated and supervised from the existing control room. Main operations as start and stop of burners shall be made locally.

1.9 The delivery shall comprise a complete boiler plant with all auxiliary equipment according to this specification.

1.10 The tender shall comprise two alternatives; Alt. 1 with max steam generation 140 t/h and Alt. 2 with 180 t/h.

1.11 The boiler shall be provided with a electric precipitator which belongs to the delivery.

1.12 The flue gases shall be conducted to the existing concrete stack.

2. TECHNICAL DATA

2.1 Steam and feed water data

Max steam pressure	87 atg ≈ 86 bar
Max steam generation	
- Alt. 1 with coal alone	140 t/h
" oil "	70 "
- Alt. 2 with coal alone	180 "
" oil "	90 "
Steam pressure after superheater	73 bar
" temperature " "	515 °C
Feed water temperature before economiser	143 °C
Range for constant steam temperature after superheater with coal firing	65-100 % load

2.2 Boiler efficiency at full load with coal firing, calculated on the net heat value corresponding to a flue gas outlet temperature of	about 160 °C
Electric precipitator efficiency	90 %

2.3 Coal

Mean values for coal from different domestic sources

Net heat value	2 700 kcal/kg
Humidity	36 %
Ash	16 %
Volatile matter	27 %
Grindability	40 Hardgrove
Size	0-80 mm
Ash softening point	900 °C
Ash melting point	1 300 °C

2.4 Fuel oil

Net heat value	10 500 kcal/kg
Viscosity at 50 °C	max 6 °E
Density	0,942 kg/l
Flame point	min 65 °C
Lowest pour point	below -5 °C
Sulfur content	max 2 %

2.5 Combustion air

Max temperature in summer	30 °C
Min " " winter	-15 "
Air temperature before flue gas air heater, min at all conditions	80 °C

2.6 Feed water

The feed water consists of demineralised make-up water alone or in a mixture with high quality condensate.

Resistance at 25°C	1 µmho/cm
Content of SiO_2	0.03 mg/l

2.7 Auxiliary steam

Bleeding steam 1, normal pressure	13 bar
" temperature	200 °C
Bleeding steam 2, normal pressure	7.5 bar
" temperature	175 °C
Back pressure steam, normal pressure	4.2 bar
" temperature	160 °C

The use of back pressure steam should be preferred before the bleeding steam, and the bleeding steam 2 should be preferred before the bleeding steam 1.

2.8 Auxiliary electric power

3-phase motors bigger than about 200 kW	6.3 kV, 50 Hz
3-phase motors less than 200 kW	380/220 V, 50 Hz
1-phase motors up to 0.5 kW	220 V, 50 Hz

More detailed information is given in pt 4.12 and in Appendices 1 and 2.

2.9 Cooling water

Quality	Untreated river water
Temperature max	20 °C
" min	0 "

2.10 The following technical data shall be given at 100, 75 and 50 % load with coal firing when steam pressure after superheater is kept constant at 73 bar.

Steam pressure in drum

Steam temperature after superheater

Feed water temperature after economizer

Gas temperature after furnace

" " " superheater

" " " economizer

" " " air heater

Oxygen content in flue gas after air heater

Flue gas pressure in furnace

" " " after air heater

Air pressure before and after coal mills

" " " burners

Air flow

Flue gas flow

Electric power consumption

Dust in flue gases before and after the electric precipitator

2.11 The following technical data must be given for the blowers

Flow

Temperature

Total pressure

Static pressure

Rpm, normal and max

Shaft power

Electric motor power

Moment of inertia

Type of control

2.12 The height of the concrete stack is 150 m

3. TECHNICAL GUARANTEES

3.1 Conditions for the guarantees

Steam pressure after superheater	73 bar
" temperature " "	515 °C
Feed water temperature before superheater	143 °C
Air temperature before air fan	10 °C
" " " flue gas air heater	80 °C

Coal quality according to pt 2.3

Fuel oil quality according to pt 2.4

3.2 Steam generation capacity with coal firing alone

Max continuous load

- Alt. 1	120 t/h
- Alt. 2	160 "

Peak load during two hours (= full load 100 %)

- Alt. 1	140 t/h
- Alt. 2	180 "

3.3 Steam generating capacity with oil firing alone

- Alt. 1	70 t/h
- Alt. 2	90 "

3.4 Net efficiency with coal firing at 50 and 100 % load.

3.5 Flue gas temperature and oxygen content after air heater with coal firing at 50 and 100 % load.

3.6 Pressure drop on steam side in superheater and on water side in economizer at full load.

3.7 Flue gas pressure drop between furnace and after air heater at full load with coal firing, before and after normal cleaning of the heating surfaces.

3.8 Ash content in flue gases before and after dust precipitator with coal firing at 50 and 100 % load.

3.9 Consumption of steam or of compressed air for soot blowing. Nominal momentaneous value and mean value during max contineous load.

3.10 The surface temperature of boiler walls, insulations of pipes and conducts does not exceed 25°C over the ambient air temperature of 20°C. At special places where proper insulation cannot be done, a higher surface temperature may be permitted.

3.11 Quality of superheated steam

Content of SiO_2	0,02 mg/kg
" " Na	0,01 "

The tenderer shall prescribe the contineous blow-down and the boiler water quality.

3.12 The steam temperature after superheater with coal firing can be kept constant at 515°C in the load range 65-100 %. The variations in the controlled temperature do not exceed 515 ± 10°C.

3.13 The consumption of electric power for internal use with coal firing at 50 and 100 % load.

3.14 The capacity of the steam or circulating hot water air heater is sufficient to heat in incoming air from -15°C to 80°C at full load with coal firing.

4 SPECIAL EQUIPMENT WHICH BELONGS TO THE DELIVERY

4.1 BOILER

4.1.1 The boiler shall be of the suspended type and the furnace designed for balanced draught.

4.1.2 All drums and headers shall be cleaned with sand blasting.

4.1.3 All boiler tubes shall be connected to welded studs in drums and headers.

4.1.4 The water walls of the furnace shall be all-welded and gas-tight.

4.1.5 The furnace walls shall be designed to withstand a flue gas pressure of ± 500 mm Wg. If the forced and induced fans at abnormal conditions could raise pressures which could damage the furnace walls, means should be prepared to avoid such abnormal conditions.

4.2 SUPERHEATER

4.2.1 The desuperheating shall be made with injection of feed water.

4.2.2 The start-up steam pipe between the superheater outlet and the free air shall be provided with electric governed shut and control valves, which shall be governed from the control room.

4.2.3 The start-up pipes and the security valves on the superheater outlet shall be conducted to the free air through a silencer.

4.3 ECONOMIZER

The economizer shall be made of horisontal steel tubes. In places where the flue gas temperature can be below 200°C the economizer tubes shall be of the compound (steel/cast iron) type.

4.4 AIR HEATER

4.4.1 The flue gas air heater shall be made of cast iron.

4.4.2 Before entering the flue gas air heater the combustion air shall be heated to 80°C in a battery with steam or circulating hot water.

4.5 COAL BURNING EQUIPMENT

4.5.1 Coal bunker made of steel with a gross volume of 600 m^3. Coal balance and coal transporters of the rubberband type on the top of the bunker. The bunker shall be provided with 3 outlet feeders, one feeder for every coal treatment line.

4.5.2 Coal mills of hammer type. As an alternative can coal mills of another type be offered. The number of mills shall be three and the capacity of each mill shall be 50 % of boiler full capacity.

4.5.3 Coal burners with flame control.

4.5.4 Pipes for pulverized coal.

4.6 OIL BURNING EQUIPMENT

4.6.1 The oil heating and pumping shall be made in two separate lines, each designed for 25 % of boiler capacity.

4.6.2 Oil burners, possibly combined with the coal burners. Every burner shall be provided with flame control.

4.7 SOOT BLOWING

4.7.1 The soot blowing shall be automatic and provided with remote control.

4.7.2 In the superheater soot blowers using steam or compressed air shall be used.

4.7.3 In the economizer and air heater the cleaning shall be made by steam, compressed air, steel shot or aluminium shot.

4.7.4 In case of compressed air as cleaning medium the compressors and complete air system are included in the delivery.

4.8 THERMAL ISOLATION

The isolations shall be covered with galvanized steel plate. The thickness of the plate shall correspond to the local need, and the thickness shall be stated in the offer.

4.9 BLOWERS

4.9.1 Every one of the three coal treatment lines shall be provided with its own forced air fan, designed for lina full capacity.

4.9.2 The oil burners shall be provided with a separata fan.

4.9.3 The boiler shall be provided with two induced draft fans for the flue gases, each fan designed for 60 % load.

The fans shall be provided with automatically governed dampers to assure secure run with only one fan working.

4.10 FITTINGS

All necessary fittings are included in the delivery. To the offer shall be attached a detailed list of fittings included. For the high pressure parts fittings with welded connections shall be prefarred. Small fittings immediately connected with the pressure parts of the boiler shall be of the best quality possibla and shall be separately indicated in the offer.

4.11 DUST PRECIPITATOR (separate price)

4.11.1 The dust precipitator shall be of the electrostatic type. The precipitator shall be divided in two lines, every line designed for one induced draft fan. The precipitator shall be provided with dampers in order to make possible service works in one precipitator, when the other precipitator is running.

4.11.2 All necessary electric equipment belongs to the delivery.

4.11.3 Under the precipitators hoppers with extraction feeders for the precipitated dust shall be placed.

4.12 ELECTRIC EQUIPMENT

4.12.1 All electric equipment shall be delivered according to the appendix 1. "Requirements for electrical equipment and installations".

4.12.2 Electric motors, 6 kV and 380 V switchgears, control equipment and panels according to the Appendix 2 "Specification for electric equipment belonging to steam boiler.

4.13 NOISE LEVELS

Fans, blow-out and safety valves shall not produce noises in excess of the recommendations of the National Institute of Public Health as applying to nearby polulated areas. The noise of boiler fans, pumps and other equipment shall not exceed curve N 85 in the boiler house.

4.14 CONTROL EQUIPMENT (separate price)

4.14.1 All local equipments belong to the delivery. The choice of type and manufacturer shall be made in consultation with the buyer.

4.14.2 The necessary remote instrumentation and control belong to the delivery. In the control room shall i.a. the following instruments be placed.
(I = indicating, R = recording, C = controlling)

Steam pressure after superheater	I
" temperature " "	IRC
" flow " "	IRC
Feed water temperature, several points	I
" " flow	IR
Flue gas temperature, several points	I
" " " after air heater	IR
" " O_2-content	IR
Draft, several points	I
Draft in furnace	IRC

Drum water level, 3-point control	IRC
Coal feeders	IC
Oil flow	IC
Air temperature and pressure, several points	I
Air temperature in coal mills	IR

4.14.3 In the delivery is included all cables and panels.

4.14.4 The instruments in the control room shall be of the min-type. To the control room is not allowed presaurized water, steam and oil.

4.14.5 To the offer shall be attached a list of all instruments belonging to the delivery.

4.15 STEEL CONSTRUCTIONS AND BUILDINGS (separate price)

4.15.1 The new boiler shall be installed outdoors and placed in line with the existing boilers and beside the existing boiler No 4. The new boiler shall be provided with a roof, which belongs to the delivery.

4.15.2 The coal bunkers for the new boiler shall be placed in line with the existing coal bunkers.

4.15.3 The steel constructione for supporting the boiler, boiler roof and coal bunker belong to the delivery. When designing the steel constructions the same levels shall be used as in the existing boiler house. The main levels are

- Basement floor ± 0 m
- Main operating floor + 6,5 m
- Coal bunker top + 24,0 m

The existing boiler house appears from the attached drawings K-01.036.00 and K-01.036.14.

4.15.4 Housing for equipment which has to be placed indoors, as coal and oil treatment, burners, etc, belongs to the delivery. The housing shall be made of steel construction with walls of panels with insulation corresponding to 50 mm mineral wool.

4.16 GALLERIES, LADDERS, PROTECTIVE RAILINGS

4.16.1 All galleries and ladders necessary for the attendance and inspection of all important equipment is included in the delivery.

4.16.2 The burner plane shall be designed for a load of 1000 kg/m^2 or a point load of 3 t. Other galleries and ladders shall be designed for 250 kg/m^2.

4.16.3 The minimum width for the galleries shall be 900 mm and for the ladders 700 mm. The slope of the ladders shall normally not exceed 45°. The maximal vertical height between resting planes shall be 4 m.

4.16.4 The surface of the galleries and the length of the ladders shall be stated in the offer. Price for additional delivery of galleries and ladders shall be stated in the offer.

4.17 PIPELINES

4.17.1 Pipe for superheated steam between boiler superheater outlet and one of the existing high pressure headers in the turbine cellar. There are two existing high pressure headers, which of them shall be used for the connections cannot for the moment be desided. Pipe size 250 mm inner diameter. Separate price.

4.17.2 Feed water pipe between the existing feed water header in the feed water pumping room and boiler feed water inlet. Pipe size 200 mm inner diameter. Separate price.

4.17.3 All other pipes belonging to a complete boiler aggregate, i.a. oil pipes, soot blowing pipes, drainage pipes, continuous blow down etc.

4.17.4 The pipe delivery shall be complete with supports, erection, insulation and fittings. As the final placing and length of pipes it is not possible to decide for the moment, the bidder can give a fixed price plus an additional price for unit tube length.

4.18 PAINTING

All machinery with the exception of parts of aluminium, stainless steel, galvanized plate, shall be sand blasted and painted with Epoxy-paint. The buyer will paint bigger machinery after the erection. All rust protecting treatment shall be made by the seller and the protection shall last one year.

4.19 SLAG EXTRACTION

The slag extraction equipment belongs to the delivery.

5 SCOPE OF DELIVERY

5.1 The delivery comprises a complete steam generator plant including transport of goods, erection, cleaning, pressure tests, chemical cleaning, start-up and 6 weeks test run during 24 h/day.

5.2 CONDITIONS FOR THE ERECTION

5.2.1 The unloading and transport of goods from waggon to the erection site belongs to the buyer.

5.2.2 All tools and erection equipment as cranes, air compressors, scaffoldings etc belongs to the seller.

5.2.3 All skilled personnel belongs to the seller. The unskilled personnel belongs to the buyer but in the tender shall be stated the amount of unskilled personnel.

5.2.4 The electric power and water needed in the erection belongs to the buyer.

5.2.5 The heating of the erection site belongs to the seller.

5.2.6 All concrete foundations belong to the buyer.

5.2.7 Baracks for the seller's personnel belong to the buyer. Against payment the buyer can also arrange office and storage rooms.

5.3 The delivery shall be made according to Yugoslavian law and regulations.

5.4 The guarantee time is two years after the acceptance of the plant.

5.5 BOUNDARIES OF THE DELIVERY

5.5.1 Feed water. Connection at the feed water header in the feed water pumping room.

5.5.2 High pressure steam. Connection at the high pressure header in the turbine house cellar.

5.5.3 Drainage. Drainage tank blow-off pipe outlet in free air and drainage tank drainage pipe stop valve outlet side.

5.5.4 Combustion air. Air inlet before the forced draft fans.

5.5.5 Flue gas connection at the concrete stack.

5.5.6 Cooling water. From one connection point in the boiler house.

5.5.7 Fuel oil. From one connection point before the heating and pumping station.

5.5.8 Coal. Inlet side of coal balance on the top of the coal bunker.

5.5.9 Slag. The slag extraction equipment outlet side.

5.5.10 Fly ash. Fly ash feeder outlet side under the precipitators.

5.5.11 Electric equipment. Se appendices 1 and 2.

5.5.12 Buildings. Connections to the concrete foundations.

6 TENDER

6.1 The offer shall in 3 copies reach Fabrika Celuloze i Viskoze, Banja Luka, Yugoslavia, latest the 1 May 1973 and then be valid in 6 months. A copy of the offer shall be sent to AB Energikonsult, Box 703, 101 31 Stockholm 1, Sweden.

6.2 The price and possibly separated prices should preferably be given as a fixed price. If the bidder is not able to give a fixed price, the conditions for a sliding price shall be stated.

6.3 All necessary scheme and flow sheets.

6.4 Lay-out of the plant. Drawings for the equipment with head dimensions.

6.5 Approximate weights of all equipment.

6.6 Lists of valves and other fittings, instruments, motors etc.

6.7 List of necessary spare parts with price.

6.8 List of sub-contractors.

6.9 The tender shall be given in English or German language, and the metric system shall be used.

Stockholm, 31 January, 1973

AB ENERGIKONSULT

Grels Berg

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Appendix 1

900501.02
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1972-09-07

Fabrika Celuloze i Viskoze

Banja Luka

Technical requirements for electrical equipment and installations

General requirements

Regulations and standards

The electrical equipment and installations shall comply with the Yugoslavian Electrical Code and the IEC Recommendations or VDE Standards in named order. If the standard differs from this specification, the specification shall apply.

Adaptation to environment

The air in the plant contains corrosive gases, above all SO_2 and Cl and dust especially coal dust and soot.

Electric switch- and controlgear are for that reason normally to be installed in separate rooms with good ventilation.

Technical design

Standardization

The number of types and sizes of components shall be limited as much as possible to facilitate operation and maintenance work.

Motors shall be of IEC and DIN standard sizes.

Cables, fuses and motor starters are to be coordinated with the motors according to the coordination table, drawing no. 103-900501-3007.

Motor control circuits are to be standardized according to type diagrams, drawing nos 103-900501-3005 and -3006.

The low voltage switchgears are to be equipped with standardised interchangeable units containing switch, fuses, contactor (auxiliary relay, if any) and overload relay for each motor.

Item numbering and markings are to be standardised in agreement with the customer.

Voltages för motors

3-phase motors bigger than c. 200 kW:
6 300 V, 50 Hz

3-phase motors up to c. 200 kW:
380/220 V, 50 Hz, solidly grounded system

1-phase motors up to c. 0,5 kW:
220 V, 50 Hz, solidly grounded system

Control voltages

For contactors etc.:	220 V, 50 Hz with one pole grounded
For signal lamps:	48 V, 50 Hz
For high voltage (6,3 kV and above) switches:	110 V, DC

Grounding system

Protective grounding is to be made as "Nullung" according to VDE 0100/12.65 § 10 N.

Low voltage switchgears

For the distribution of low voltage, from the transformers there are to be installed metal-enclosed switchgears containing standardised interchangeable units for switches and fuses and for different sizes of motor starters.

Principles are shown in drawings nos 103-900501-3002 and -3003.

Rated voltage:		380 V, 50 Hz
Insulation level:		3 kV, 50 Hz, 1 min.
Short time withstand current:		40 kA RMS
Peak withstand current:		100 kA ampl.
Rated current of main busbars:		2 000 A
Degree of protection:	in substations	P 21
	elsewhere	P 43
Design:	according to the standard of the contractor. It is desirable that the above-mentioned units can be exchanged without voltage interruption on the busbars.	

The feeder cubicle is to be equipped with a manually operated main circuit-breaker, amperemeter, voltmeter with voltmeter switch, and push-button for tripping of the high voltage circuit breaker of the transformer.

Each switchgear is to be equipped with a separate fuse-board with main switch for distribution of the control voltage to the different cubicles according to drawing no. 103-900501-3003.

In substations containing more than one transformer there shall be arranged an interconnection with a normally open disconnector between the 400 V busbars as a reserve feeder by transformer failures and similar situations.

<u>AC motors</u>

These rules are to be applied to new motors. Existing motors may diverge from these rules.

AC motors are normally to be totally enclosed fan cooled squirrel-cage induction motors for direct-on-line starting.

Motors shall be designed, fabricated and tested in accordance with the latest editions of IEC standards or German VDE standards.
All motors shall have IEC frame sizes.

The motor design shall normally allow at least three starts in quick succession from cold against full load without injurious heating of insulated windings.

Bearings shall preferably be ball and/or roller grease lubricated bearings.

Space heaters are to be provided for 6,3 kV motors. Supply voltage 220 V, 50 Hz. Space heater leads are to be brought out into a separate terminal box located near the main terminal box.

Degree of protection shall be at least P 33 for motors and P 43 for terminal boxes.

<u>Safety switches for motors</u>

To allow safe repair and maintenance work on motors and their correspon-ding machines all remote controlled low voltage motors are to be connected via manually operated safety switches. The safety switches shall be mounted in the immediate vicinity of the motors to avoid mistakes.

The safety switches shall:

1 be enclosed with degree of protection at least P 44

2 have a breaking capacity of at least 8 times the rated current of the motor at 110 % rated voltage and cos φ = 0,35

3 have a reliable position indicating device that safely shows the real positions of the contacts

4 in open position have a disconnecting air distance of at least 4 mm at 380 V

5 be possible to padlock in open and closed position

Control gear

Type diagram for motor control circuits are shown in drawings nos 103-900301-3005 and -3006.

The motors are to be controlled by control switches to show the ordered state of the motors. All signal lamps are normally dark but if a running motor is tripped by e.g. the thermal relay the signal lamp by the switch will start flashing and accoustical alarm will be given.

All interlocking and control circuits are to be connected in separate connection cabinets (or boxes) near the switchgears.

Components

The choice of components is to be approved by the buyer.

Fuses are to be standardised in consultation with the buyer.

Contactors are to be so dimensioned that they will not carry more than 75 % of their rated thermal current under normal conditions.

The rated thermal current of any contactor may not be less than 16 A.

Contactors are to be chosen according to at least the utilization category AC 3.

Thermal overload relays are to be installed for all motors. They shall be of plug-in type, have a separate auxiliary contact for alarm and be adjustable for manual or automatic reset.

Current transformers

Secondary current: 5 A

Amperemeters

The amperemeters for the feeders to substations and switchgears are to be equipped with a moving-iron mechanism and a 15 min. bimetallic mechanism with a trailing pointer to show the maximum demand.

Terminal boards

Terminals for measuring circuits shall be provided with an arrangement allowing an easy connection of control instruments without disconnecting wires. Terminals for current measuring circuits shall have an arrangement for short-circuit.

Terminals in the separate coupling cabinets shall be isolating terminals to facilitate testing and trouble-shooting.

Normally only one conductor is allowed on the external side of each terminal. On the internal side two conductors are allowed on each terminal. All connections between terminals are to be done on the internal side. In each unit (panel, cubicle etc.) there shall be room for at least 10 % spare terminals or at least five terminals for future connection.

Cables and wires

The following types of cable are to be used:

Low voltage power cables indoors:	NYY
" " " " underground:	NYYBY
Control cables:	NYY
High voltage power cables:	NEYYBY

The cables are normally to be installed on cable racks or trays of galvanized steel (or equivalent). Installation in cable channels in the floors shall be avoided.

Internal control connections are to be made with PVC-insulated tin-plated 1,5 mm^2 wires.

Item numbering and marking

All equipment is to be provided with item numbers, which are to be found in specifications and drawings.

Cables shall be marked with cable numbers in both ends. Those cable numbers are to be found in cable lists and wiring lists (or diagrams).

Internal connections in cubicles, panels etc. shall be marked according to drawing no. 103-900501-3004 or equivalent. The marking are to be found in the corresponding lists and diagrams.

Markings, signs, warning boards etc. shall be of durable material and with text in the local language.

Drawings

Drawings for the electrical equipment shall be made according to DIN 40719 or equivalent standard. If the text is not in the local language there shall be space reserved for translation.

All dimensions shall be given in the SI system.

The following diagrams and drawings are to be delivered:

Erection drawings
List of equipment (preferred size: A3)
Block diagrams
Circuit diagrams (preferred size: A3)
Wiring lists or diagrams
Cable lists (preferred size: A3)
Position drawings
List of drawings

Drawings according to the real design and necessary instructions, descriptions etc. shall be delivered as soon as the equipment gets ready for service. One set of copies and documents shall be delivered for examination and approval in connection with the final inspection.

After that two sets of copies and one set of transparent final drawings are to be delivered in suitable covers.

Appendix 2

AB [illegible]

900501.02
E-SDg/Os
1973-01-09

Fabrika Celuloze i Viskoze

Banja Luka

Specification for electric equipment belonging to steam boiler

General

The electric equipment shall comply with "Technical requirements for electrical equipment and installations".

./.

Boundaries of delivery

The delivery shall include

- all motors for coal mills, fans burners pumps and other machinery within the delivery
- 6 kV switchgear for high voltage motors according to specification below
- 380 V switchgear for low voltage motors and other auxiliary electric equipment. For further details see "Technical requirements .." mentioned above.
- necessary equipment for control, regulating and interlocking of the boiler
- control panel in the central control room with instruments, annunciator etc. for supervision of the boiler
- delivery and installation of all power and control cables between equipment included in the delivery
- drawings and instructions according to "Technical requirements .." mentioned above

The delivery is limited by the terminals for the feeder cables in the 6 kV and 380 V switchgears.

Specification for 6,3 kV switchgear for new boiler

The switchgear is intended for highvoltage motors for coal mills, feed water pumps and fans for one new boiler.

"Technical requirements for electrical equipment and installations" shall apply where relevant.

Standard:	IEC 298
Type:	Factory assembled metal-clad or cubicle switchgear for indoor installation with one set of busbars. Circuit breakers shall be withdrawable.
Rated voltage:	7,2 kV
Rated insulation level:	According to IEC 298, table II
Rated short circuit power:	250 MVA at 6,3 kV
Degree of protection:	IPW 6
Control voltage:	110 V, DC

The cubicles shall be so designed that the flames and gases from a short circuit are inside the cubicle are discharged in a direction that is harmless to the operating staff.

Feeder cubicle containing

1 withdrawable, remote controlled circuit breaker with spring operating mechanism for motor loading. Motor voltage 110 V, DC. Making and breaking capacities may not be less than 250 MVA at 6,3 kV and shall be verified by test reports.

1 voltage transformer 6 600/110 V for measuring the voltage before the circuit breaker

2 fuses 6,3 kV for voltage transformer

1 voltmeter on the front of the cubicle

Control switches and levers for local operating of the circuit breaker.

Necessary fuses, terminals etc. for control and measuring circuits.

<u>Cubicles for motor starters</u> (one for each motor) each containing:

1 withdrawable, remote controlled circuit breaker as above suitable for switching of motor currents without initiating harmful over-voltages

2 current transformers .../5 A

2 thermal overload relays for the high voltage motor

2 overcurrent relays as short circuit protection for the high voltage motor

2 amperemeters on the front of the cubicle

Control switches and levers for local operating of the circuit breaker.

Necessary fuses, terminals etc. for control and measuring circuits.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, VIENNA

CONTRACT 71/50

Report 1 — **REPORT CONCERNING THE ENLARGEMENT OF THE INDUSTRIAL STEAM POWER STATION IN THE INDUSTRIAL COMPLEX "FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA"**

Appendix 7 — Specification for the delivery of a back pressure steam turbine of 12 resp. 23 MW

No appendices included. For "Technical requirements for electric equipment and installations", see Appendix 3 No 6 according to index.

AB ENERGIKONSULT

FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA

SPECIFICATION FOR THE DELIVERY OF A BACK
PRESSURE STEAM TURBINE OF 12 RESP. 23 MW

INDEX

Appendices

Drawings:

K-01.036.00 }
K-01.036.14 } showing the existing power plant

AB [illegible]

900501
P-Beg/SL

FABRIKA CELULOZE I VISKOZE, BANJA LUKA, YUGOSLAVIA

SPECIFICATION FOR THE DELIVERY OF A BACK
PRESSURE STEAM TURBINE OF 12 RESP. 23 MW

1 CONDITIONS OF OPERATION

1.1 The existing industrial steam power station in Banja Luka provides steam and electric power to a combinate consisting of factories for the production of dissolving pulp (Ca basis), paper, rayon, high wet modulus fibers, cellophan, NaCl electrolysis. The plans for the nearest future are to connect to the power station new factories for the production of light concrete and polyester which factories already are under construction, and possibly expand the existing pulp mill.

1.2 The existing steam power station consists of four boilers with a max steam generating capacity of 70 t/h each and of three steam turbines of back pressure or extraction-condensing type. The installed steam generating capacity will not be sufficient for the future need and therefore the steam power station will be enlarged with a new boiler and with a new back pressure turbine according to this specification.

1.3 All boilers and turbines in the existing station are made for the same high pressure steam conditions and are interconnected on the high pressure side. The new boiler and turbine shall be made for the existing high pressure steam conditions, and they shall be connected to the existing high pressure net in order to make parallel run possible.

1.4 The new turbine shall in parallel with the existing turbine and reduction valves control the steam pressure in the bleeding steam net 13 bar, bleeding steem net 7.5 bar and back pressure net 4.5 bar.

1.5 The tender shall comprise two alternatives, Alt. 2 with generator capacity 12 MW and Alt. 3 with 23 MW. In Alt. 2 shall the new turbine be placed in line with the existing turbines in an enlargement of the turbine house beside the existing turbine No 3. In this case will the new turbine be placed opposite the place for the new boiler. In Alt. 3 the new turbine shall be placed in the existing turbine house, on the place for the existing turbine No 1 which shall be discharged.

1.6 In alternative 2 shall the turbine house of steel construction be enlarged with the same dimensions in height 18 m and width 15 m as in the actual turbine house.

1.7 The time of operation will be about 8 000 h/year.

1.8 On the electric side shall the new turbine be able to run alone or in parallel with the existing turbines and with the grid.

1.9 The new turbine shall be operated and supervised from the existing control room. Main operations by start and stop shall be made locally.

2 TECHNICAL DATA

2.1 STEAM DATA

Steam pressure before turbine nozzles	70 bar
" temperature " " "	515 °C
Steam flow at full load	
- Alt. 2	80 t/h
- Alt. 3	150 "
Bleeding No 1, normal pressure	13 bar
max. "	15 "
max. steam flow, Alt. 2 and 3	30 t/h
Bleeding No 2, normal pressure	7.5 bar
max. "	9.0 "
max. steam flow only Alt. 3	15 t/h
Back pressure, normal pressure	4.5 bar
max. "	6.0 "
max. steam flow	
- Alt. 2	80 t/h
- Alt. 3	150 "

2.2 EXTREME STEAM DATA

Design pressure of boilers	86 bar
Max. steam temperature	525 °C

2.3 COOLING WATER

Quality, untreated river water	
Temperature, max.	25 °C
" min.	0 °C

2.4 AUXILIARY ELECTRIC POWER

3-phase motors bigger than about 200 kW	6.3 kV, 50 Hz
3-phase motors up to about 200 kW	380/220 V, 50 Hz
1-phase motors up to about 0.5 kW	220 V, 50 Hz

For detailed information, see Appendix 1.

3 TURBINE REGULATORS

The following regulators are included in the delivery.

3.1 Speed regulator which can be controlled by hand at the turbine as by remote control from the panel room.

3.2 Bleed steam No 1 regulator by which the bleeding pressure can be set between 12-15 bar.

3.3 Bleed steam No 2 regulator by which the bleeding pressure can be set between 7-9 bar. This regulator concerns only the turbine in Alt. 3.

3.4 Back pressure regulator by which the back pressure can be set between 4-6 bar.

3.5 In the offer for the steam pressure regulators the deviations from the set point shall be stated.

3.6 As the bleeding flows are small compared with the back pressure flow, the bidder has to decide if the bleeding possibly shall be regulated by trottling the bleeding steam.

4 SPECIAL EQUIPMENTS WHICH BELONG TO THE DELIVERY

4.1 The turbine and the generator shall be provided with a common pressurized oil system for lubrication and governing. The oil system shall comprise the following pumps.

4.1.1 One pump for normal run, driven by the turbine shaft.

4.1.2 One pump for normal start and stop driven by a.c.motor.

4.1.3 One pump for emergency stop, driven by a steam turbine. This pump shall be provided with automatic start controlled from the oil pressure.

4.2 The turbine and the generator shall be provided with a complete security and alarm system. In the offer shall be stated which disturbances lead to alarm and which lead to automatic shut-off of the aggregate.

4.3 Two oil coolers, designed for 100 % load each. It shall be possible to interchange and maintain the coolers during operation. The control equipment for regulation of the oil temperature during start-up and normal run shall be included in the delivery.

4.4 Electric turning gear.

4.5 Leakage cooler of indirect type.

4.6 Ventilation aggregate needed to keep the aggregate dry during shut down.

4.7 Steam filter before turbine admission nozzles.

4.8 Check valves in bleeding lines.

4.9 The turbine and the generator shall run at 3000 rpm.

4.10 The thermal insulation shall be covered with galvanized or polished steel plate. The plate thickness shall be stated in the offer. The insulation shall be designed for a temperature difference of 25°C between ambient air and insulation surface.

4.11 The admission steam pipe between a high pressure header in the turbine house cellar and the turbine. Separate price.

- Alt. 2. inner diameter 200 mm Ø; the new high pressure header will be in the enlargement of the turbine house cellar near the new turbine.

- Alt. 3. inner diameter 250 mm Ø; the existing high pressure header is placed in the existing turbine house cellar near the new turbine.

4.12 The bleeding No 1 steam pipe between the new turbine and the bleeding No 1 steam header placed in the existing turbine house cellar. The inner diameter shall be 250 mm (13 bar, 30 t/h, 27 m/s). Separate price.

4.13 The bleeding No 2 steam pipe between the new turbine and the bleeding No 2 steam header in the existing turbine house cellar. The inner diameter shall be 250 mm (7.5 bar, 15 t/h, 23 m/s). This concerns only the turbine in Alt. 3. Separate price.

4.14 The back pressure steam pipe between the turbine and the back pressure header in the existing turbine house cellar. Separate price.

- Alt. 2. inner diameter 600 mm (4.5 bar, 80 t/h, 40 m/s).

- Alt. 3. inner diameter 800 mm (4.5 bar, 150 t/h, 40 m/s).

4.15 The pipe delivery shall be complete with supports, erection, insulation , bellows, fix points and fittings. As the final placing and length of the pipes is not possible to decide for the moment, the bidder can give a fixed price plus an additional price for unit tube length.

4.16 PAINTING

All machinery with the exception of parts of aluminium, stainless steel, galvanized plate, shall be sand blasted and painted with Epoxy-paint. The buyer will paint bigger machinery after the erection. All rust protecting treatment shall be made by the seller and the protection shall last one year.

4.17 The concrete turbine foundations do not belong to the delivery. At a separate price shall be offered the constructional drawings for the turbine foundations.

4.18 In the Alt. 2 is included in the delivery the extension of the turbine house made of steel construction. The extension shall have the same dimensions in height and width as in the existing turbine house.

The main levels are

Basement floor	± 0	m
Main operating floor	+ 6,5	"
Turbine Crane rail upper side	+ 14.4	"
House roof	+ 18.4	"

The turbine house walls shall be made of insulated steel plates with an insulation corresponding to 50 mm mineral fiber. In the delivery is also included the enlargement of the rail for the turbine house crane. The dimensions of the existing turbine house appears from the attached drawings K-01.036.00 and K-01.036.14. Separate price.

4.19 CONTROL EQUIPMENT

All local equipment is included in the delivery. In the delivery is also included a panel placed in the existing control room with all instruments needed for supervision and operation of the turbine. In the delivery is included the erection, erection materials and cables.

5 TECHNICAL REQUIREMENTS FOR SYNCHRONOUS GENERATOR AND ELECTRICAL EQUIPMENT BELONGING TO BACK PRESSURE TURBINE

5.1 STANDARDS AND REGULATIONS

Generator and electrical equipment shall be made and tested according to IEC Recommendations and fulfil the requirements in Yugoslavia laws and regulations.

5.2 GENERATOR AND EXCITER

Rated power = the maximum output of the turbine, i.e. 12 alt. 23 MW

Power factor:	0.8
Frequency:	50 Hz
Rated voltage:	10 kV. The generator will be connected to 22 kV via unit transformer
Connection:	Y-0 with both ends of all windings brought out to terminals

The generator shall be completely closed with a closed air cooling system with air/water coolers. The housing shall be designed to make the stator windings accessible for cleaning. Proper inspection doors shall be placed where regular inspections are needed.

The stator windings shall be so designed that the replacement of a damaged coil can be carried out on the installation site and so that either end of the windings can be used as neutral point.

The generator shall be equipped with a connection box for cables or bus bars with room for current transformers.

To permit temperature measurements at least 6 RTD's shall be placed in the slots on places where the highest temperatures may be expected and one in the cooling air after the cooler. The connecting wires shall be drawn to well marked detachable terminals in a common terminal box.

All bearings shall be provided with RTD's built into the bearing metal for temperature control and with pressure sensors for oil pressure control. The RTD's shall be connected to the above mentioned terminal box.

Precautions shall be taken against dangerous bearing currents. If such currents occur they shall be recorded. Electrical wiring for measuring of the bearing voltage shall be drawn into a connection box on the generator.

The generator shall be provided with a separate excitation rectifier fed from the auxiliary network or an AC exciter with rotating diodes.

The excitation system shall be complete and be provided with an automatic voltage regulator and manual control. Alternative excitation systems may be offered.

5.3 PROTECTION SYSTEM FOR THE GENERATOR

The generator shall be proved with the following protection systems:

Differential protection

Stator earth fault protection

Interturn fault protection (if necessary)

Overvoltage protection

Stator overload protection

Reverse power protection

Over current protection or minimum impedance protection

Minimum voltage protection

Rotor earth fault protection

Assymetrical load protection

Diode supervision (only for rotating diodes)

Minimum frequency protection (turbine protection)

The protection relays are to be mounted in separate cabinets and be provided with arrangements for testing of all circuits and relays. There shall be indicating devices for visual indicating of occuring functions.

The delivery shall include the necessary measuring transformers and wiring for a complete protection system.

A neutral point equipment with resistor for limitation of the earth fault current to a harmless value, 10 A at solid earth fault, shall be included in the delivery.

5.4 CONTROL PANEL

A control panel shall be installed in the existing control room. It shall contain the following equipment:

a) Control instruments for generator and exciter

b) Remote governor and indicator for field circuit breaker

c) Hand-automatic switch for voltage regulator

d) Switches (or similar) and instruments for adjustment of generator voltage

e) Push-buttons for speed control

f) Governing equipment for switching between back pressure and speed control

g) Temperature recording of all measuring points

h) Push button for emergency tripping of the aggregate

i) Annunciator for turbine and generator

5.5 OTHER ELECTRIC EQUIPMENT

Voltages for motors and control systems are prescribed in "Requirements for electrical equipment and installations".

In the delivery shall be included all necessary sensors and manoeuvring equipment for a complete security and alarm system.

In the delivery shall be included all electric motors inside the boundaries of delivery.

The turbine speed regulator shall be provided with a motor for turbine speed adjustment.

Switchgears with motor starters for all motors shall be included in the delivery.

In the turbine control panel to be included in the delivery shall be mounted push-buttons, switches, signal lamps etc needed for start-up, normal run and shot down of the turbine.

Equipment mounted outside panels e.g. position switches, thermostats and similar shall be of closed design and placed accessible for inspection and adjusting during operation. It shall be designed and mounted regarding the vibrations which can occur and be suitably surface protected against possible chemical attack.

5.6 MARKING. DRAWINGS AND DESCRIPTIONS

Labels, markings and drawings shall be made according to "Requirements for electrical equipment and installations".

A technical description of all electric equipment shall be included in the delivery. It shall in principle contain the following items.

General introduction

Description of function suitable for nonprofessionals

Detailed description of function suitable for electric service personnel

Attendance prescriptions i.a. lubrication instructions and service list for periodic maintenance

Instruction for fault searching

Instruction for installation

Spare parts list with proposal for spare storage list

Technical data, test reports, adjustment data etc.

5.7 TESTING

The generator and exciter shall be tested in the contractors workshops and the following tests are to be made:

a) Overspeed test

b) No load and short circuit curves

c) Load point at rated voltage and current at power factor = 0 over excited

d) Control of the curve form of the voltage

e) Losses (type test report can be accepted)

f) Reactances -"-

g) Heat run -"-

h) Dielectric tests

j) Sudden short circuit test at rated voltage (only on special requist)

The contractor shall keep the purchaser informed of the testing program and the purchasers representative shall be allowed to be present at the tests.

5.8 BOUNDARIES OF DELIVERY

The delivery is limited by

a) the terminals of the generators

b) the feed point of switchgears and cabinets for auxiliary equipment

The delivery shall include delivery and installation of all cables between equipment included in the delivery.

5.9 INFORMATION FROM TENDERER

Tenders shall contain the following data:

a) Temperature rise in stator and rotor windings at rated load

b) Description of windings and insulation.
Class of insulation

c) Reactances (X_d, X_d' , X_d'') and short circuit ration

d) Maximum reactive power output at power factor = 0

e) Possible deviations from specified standards

f) Technical description of excitation and supervision equipment

g) Power consumption for auxiliary equipment

h) Motor list

j) List of necessary spare parts with prices

6 POWER TRANSFORMER (Separate price)

6.1 RATING

1 oil-insulated three-phase power transformer for out of doors use as unit transformer for turbo-alternator.

Standards:	IEC 76
Rated power	16 alt. 31.5 MVA
Rated voltage ratio	23 kV ± 2 x 2.5 %/10 kV
Frequency	50 Hz
Insulation levels	
high voltage winding:	125-50 kV
low voltage winding:	75-28 kV
Vector group	YNd 5
Type of cooling	ONAN/ONAF/OFAF
Load losses	to be stated in tender
No-load losses	to be stated in tender
Power demand of cooling equipment	to be stated in tender

6.2 ACCESSORIES

The terminals shall be enclosed and suited for connection of cables or/and insulated busbars.

The transformer shall be equipped with

- oil concervator with dehydrating breather, level indicator and alarm contact for low level
- Buchholz relay with contacts for alarm and tripping
- off-load tap changer with actuator accessible from the ground level
- Thermometers for top oil and winding temperatures with two separate contacts for alarm and tripping
- a complete cooling system including all necessary electric equipment (fuses, motor starters etc.) mounted in a tight box or cabinet on the transformer
- wheels and lifting lugs
- earthing terminals on both sides of the transformer tank
- all valves and flanges necessary for filling, emptying, sampling and filtering the oil
- Thermometer wells for control thermometers. When not used they are to be protected by a plug or cover.

6.3 TESTS

All routine tests according to IEC 76 are to be made.

For test of temperature rise and full-wave impulse-voltage withstand test reports from type tests of an identical transformer will be accepted. If no such reports are available type tests are to be made.

The contractor shall keep the purchaser informed of the testing program and the purchaser's representative shall be allowed to be present at the tests.

6.4 BOUNDARIES OF DELIVERY

The delivery includes the transformer incl. specified accessories and insulating oil assambled on site in Banja Luka excl. external electrical connections.

6.5 INFORMATION FROM TENDERER

Tenders shall i.a. contain the following data:

a) Load losses and no load losses

b) Impedance voltage

c) Power demand for cooling equipment

d) Weights and measures

7 GUARANTEES

7.1 CONDITIONS FOR THE GUARANTEES

Steam pressure before turbine nozzles	70 bar
" temperature " " "	515 °C
Bleeding No 1 steam pressure	13 bar
" " 2 " "	7.5 "
Back pressure	4.5 "
Power factor	0.8

7.2 THE GENERATOR POWER SHALL BE GUARANTEED AT THE FOLLOWING POINTS

Turbine Alt. 2.

Point	Admission steam t/h	Bleeding No 1 steam t/h
a	80	0
b	80	20
c	80	30
d	60	20
e	40	20

The generator power shall be weighted according to the following formula

$$\frac{a + 3b + c + 3d + 3e}{11}$$

Turbine Alt. 3

	Admission steam t/h	Bleeding No 1 steam t/h	Bleeding No 2 steam t/h
a	150	0	0
b	150	20	10
c	150	30	15
d	120	20	10
e	90	20	10

The generator power shall be weighted according to the following formula formula

$$\frac{a + 3b + c + 3d + e}{9}$$

7.3 The leakage steam is included in the admission steam. The amount of leakage steam shall be stated and quaranteed.

7.4 To the offer shall be attached a diagram showing the generator power in the region 0-100 % as a function of steam flow. The diagram shall also show curves for the bleedings. By nozzle control shall the points for full opened nozzles be indicated in the diagram.

8 SCOPE OF DELIVERY

8.1 The delivery comprises a complete turbine plant including transport of goods, erection, cleaning, pressure tests, chemical cleaning, start-up and 6 weeks test run during 25 h/day.

8.2 CONDITIONS FOR THE ERECTION

8.2.1 The unloading and transport of goods from waggon to the erection site belongs to the buyer.

8.2.2 All tools and erection equipment as cranes, air compressors, scaffoldings etc belongs to the seller.

8.2.3 All skilled personnel belongs to the seller. The unskilled personnel belongs to the buyer but in the tender shall be stated the amount of unskilled personnel.

8.2.4 The electric power and water needed in the erection belongs to the buyer.

8.2.5 The heating of the erection site belongs to the seller.

8.2.6 All concrete foundations belong to the buyer.

8.2.7 Baracks for the seller's personnel belong to the buyer. Against payment the buyer can also arrange office and storage rooms.

8.2.8 The turbine house crane with a lifting capacity of 30/8 t is available at the erection.

8.3 The delivery shall be made according to Yugoslavian law and regulations.

8.4 The guarantee time is two years after the acceptance of the plant.

8.5 BOUNDARIES OF THE DELIVERY

8.5.1 High pressure steam. Connection to the high pressure header.

8.5.2 Bleeding No 1 steam. Connection to the existing bleeding No 1 header 13 bar in the turbine house cellar.

8.5.3 Bleeding No 2 steam. Connection to the existing bleeding No 2 header 7.5 bar in the turbine house cellar.

8.5.4 Back pressure steam. Connection to the existing back pressure header 4.5 bar in the turbine house cellar.

8.5.5 Drainage. All drainages shall be conducted to a drainage tank in the boiler room. The tank is not included in the delivery.

8.5.6 Cooling water. From a connection point in the main cooling water pipe in the existing turbine house.

8.5.7 Electric equipment, see points 5 and 6 and Appendix 1.

9 TENDER

9.1 The offer in 3 copies shall reach Fabrika Celuloze i Viskoze, Banja Luka, Yugoslavia, latest the 1 May, 1973. A copy of the offer shall be sent to AB Energikonsult, Box 703, S-131 01 Stockholm, Sweden.

9.2 The price and possibly separated prices should preferably be given as a fixed price. If the bidder is not able to give a fixed price, the conditions for a sliding price shall be stated.

8.3 All necessary scheme and flow sheets.

8.4 Lay-out of the plant. Drawings for the equipment with head dimensions.

8.5 Approximate weights of all equipment.

8.6 Lists of valves and other fittings, instruments, motors etc.

8.7 List of necessary spare parts with price.

8.8 List of sub-contractors.

8.9 The tender shall be given in English or German language, and the metric system shall be used.

Stockholm, 31 January, 1973

AB ENERGIKONSULT

Grels Berg

REPORT 2

UNIDO

PRINCIPAL DESIGN OF BIOLOGICAL TREATMENT OF WASTE WATERS FROM FCVBL, BANJA LUKA

Abstract

A principal design of a waste water treatment plant for the pulp mill in Banja Luka has been made.

Production and flow data have been obtained from a KBW report (June-July 1972). Specific BOD data have mainly been taken from similar mills and from literature.

A biological treatment system has been chosen. Areas and volumes of tanks, oxygen requirements and nutrient additions have been calculated.

A description of the technical standard of the various parts of the installation has been made.

Calculation of investment costs and annual costs for two treatment alternatives have been made.

The report includes 9 drawings.

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SCANDIACONSULT
INTERNATIONAL AB
Stockholm J Rennerfelt/KB 73-06-26 58.0235-01

UNIDO

PRINCIPAL DESIGN OF BIOLOGICAL TREATMENT OF WASTE WATERS FROM FCVBL, BANJA LUKA

1. Background data

1.1. Production

The mill is going to produce viscose pulp from Yugoslav beech using acid Ca-bisulphite cooking.

The production is planned to be:

	Air dry (90 %) tons/d	
Pulp from cooking	403	incl. 6 % overcapacity
-"- after bleaching	371	-"- -"-
-"- -"- -"-	350	year mean value

1.2. Waste water flow and amount of polluting material from different departments

The production of 371 tons/d viscose pulp is expected to result in the following amounts of waste water and polluting material, measured as BOD.

Debarking

The debarking will be a cold wet-debarking. 0,4 m^3 of water is used per m^3 of wood. This corresponds to 15-16 m^3/h. The wood will mainly be fresh wood. (Yugoslavian beech.)

Cooking

The raw material is Yugoslavian beech and the digestion is made in seven batch digesters with 145°C maximum temperature. The yield is 42 % and the Roe number is 1-1,5. The sulphite liquor losses in the vooking department are estimated to be 3-4 %.

Washing and screening

A first screening is done before washing in a continuous diffuser. The losses of spent liquor in washing is 3 % (97 % liquor recovery), which is going with fibres to other departments. The dilution factor is 2 m^3/ton. The water from the second screening is used in the first screening. No water is discharged to the sewer.

Evaporation

The spent sulphite liquor is evaporated from 14,5 % to 56 % and 119 m^3/h is obtained as condensate, corresponding to 7,1 m^3/ton pulp.

The loss of dry matter in the evaporation process (washing of evaporation) is estimated to 1 %.

The litterature reports different specific BOD-values for condensates from hardwood. The values are said to be 40-60 kgs/ton, 80-90 kgs/ton, 45-55 kgs/ton etc. If is quite obvious, however, that hardwood condensates have a much higher BOD than softwood condensates.

A grab sample of condensate from Banja Luka (1971) gave a BOD 5 of 9 000 mg/l corresponding to a specific BOD of 64 kg/ton. As the per cent spent liquor recovery is going to be higher in the future, the specific BOD will increase. A value of at least 70 kg/ton seems reasonable. A way of decreasing this figure would be to neutralize the spent liquor before evaporation to prevent the Acetic acid from going into the condensates. This is, however, difficult in a Ca-base mill.

Bleaching

The flows from the different stages are

	Flow, l/min	temp °C
Chlorine	8 000	20
Alkaline extraction	2 500	60-65
Hypochlorite	3 000	35
Chlorine dioxide	610	55
	14 110	

The fibre loss from the first three steps is 100 mg/l and from the fourth 80 mg/l. The fibre loss from the cyclone is 0,4 kg/min.

The bleaching is done to 92 % α-cellulose and results in a loss of 8 % of the pulp.

The BOD from a bleaching operation of this type is normally about 40 kgs per ton of bleached pulp according to litterature. Analysis of a grab sample from the mill shows much lower values.

	BOD_5 mg/l	BOD_5 kg/ton
Total bleaching waste	220	23
Extraction step	780	14

These values are lower than expected, and it seems reasonable to use a value of 40 kgs/ton as the pulp is a dissolving pulp and is made from hardwood.

Other departments

The water from the wet part of the drying machine (7700 l/min) is used in the bleaching and washing departments. There are no fiber losses. On certain occasions, 2 m^3/min can be taken to treatment.

The incoming concentration is 1,2 % and the concentration before the drying part is 46 %.

334 ton/d calculated as absolutely dry pulp is produced. This means that (27 833 - 726) = 27 000 m^3/d (= 18,8 m^3/min) of water is separated from the pulp. Part of it recirculated and part of it is used in the bleaching and washing departments.

1.3 Summary of flows and polluting material

Production, Unbleached	403
Bleached	371

	Flow m^3/h	Spec. BOD_5 kg/ton pulp	BOD_5 kg/d	Susp solids kg/d
Debarking	16	3	~1 210	
Cooking, losses	-	15	6 050	
Washing, losses (SSL, not recovered)	-	15	6 050	
Losses from washing of evaporators		5	2 010	
Condensates	120	70	28 210	
Bleaching wastes	850	40	14 840	
	~1 000		58 370	

2. Permissible load to the Urbas River and required treatment efficiency

2.1. Permissible load

2.1.1 Background

The rivers in Yugoslavia have been divided into different classes according to their use. The Vrbas river downstream of Banja Luka has been placed in class III. This means that the biochemical oxygen demand (BOD_5) must not exceed 7 mg/l even at low water flow.

2.1.2 General principles

It is obvious that the total load must be shared between the city of Banja Luka (including the industries discharging their wastes into the city sewage system) and the pulp and viscose factory, leaving a certain part unused for the future extension of the city and the industries.

It is therefore necessary that treatment installations are built for the city and the pulp mill.

The city must have the right to discharge its wastewater after a treatment which is reasonable from the (present) technical standpoint in Europe.

The reserve left for the future may be used for a limited period of time by the city or the pulp mill. During this period the city or the pulp mill should investigate more efficient treatment methods and design new treament facilities.

At river flows higher than the minimum flow, the extra waste-assimilation capacity should be shared in proportion to the BOD discharge during low-flow conditions.

2.1.3. Basic data

The division of the load is proposed for low-flow conditions. The low-flow in the Vrbas river, including the Vrbanja and the city wastewater, is considered to be 33 m^3/s. This corresponds to a BOD of 231 g/s downstream the city and the pulp mill.

The population of Banja Luka is expected to be 202,000 by the year 1990. The specific BOD is calculated to be 60 g per person per day (if no household garbage grinders are installed). This is equal to 12.1 tons of BOD_5 per day.

It has been calculated that the industries of Banja Luka will discharge wastewater with a BOD of 6.2 tons/day by the year 1990. The figure is based on the estimated production in 1990 and assumes good water management within the factories. No measurements of the waste loads have been made, however.

The BOD in the Vrbas river upstream from Banja Luka is normally 1.6 mg/l (although variations frequently occur).

2.1.4. Calculation of the sharing of the load

The BOD in the Vrbas river upstream from Banja Luka is 1.6 mg/l or 53 g/s at low flow.

The total BOD from the city of Banja Luka and the city industries is estimated at 12.1 + 6.2 tons/day. The BOD from the city is assumed to be equally distributed throughout 19 hours of the day, corresponding to a BOD of 177 g/s.

The industrial waste load is generally discharged during 10-16 hours per day, but it is necessary to assume the construction of equalization tanks to permit an equal distribution during 24 hours per day. (It may even be necessary to discharge a greater proportion during the night). The industrial waste is calculated to 72 g/s. The sum of the municipal and the city industry BOD is 249 g/s. Assuming a 90 % treatment efficiency, the discharge will be 25 g/s.

It is reasonable to reserve about 25 % of the permissible waste load for future needs. This corresponds to 1.7 mg/l of BOD at low flow or 56 g/s.

The BOD which can be discharged from the pulp mill is:

231-53-25-56 = 97 g/s

This will require a very far-reaching internal and external treatment of the pulp mill wastewater.

During a limited period of time it might be necessary to use the reserve capacity of the river before adequate treatment facilities have been built.

During the final stage, however, the division of the load should be the following:

Vrbas river upstream of	City of Banja Luka	Pulp mill FCVBL	Reserve
53 g/s	27 g/s	97 g/s (8.4 ton/d)	56 g/s

2.2. Treatment efficiency

It can be concluded that the permissible load should be only 8.4 tons of BOD per day. A part of this load (2 tons/d) is occupied by the treated water from the viscose plant. This means that the efficiency of the biological treatment must be higher than 85 % if all waters are taken to biological treatment. If some waste waters are excluded, a higher treatment efficiency for the remaining waters must be obtained.

If the waste assimilation capacity reserved for the future is used, a maximum BOD of 13.2 tons/day can be discharged to the river. This reserve may have to be used during start-up periods in the mill when the waste load generally is high.

3. Design of treatment plant

3.1. Flows and BOD-load

In order to obtain a low total load on Vrbas river it is necessary to treat all waste waters from the mill listed under 1.3. This means that the following approximate amounts have to be taken to treatment. It is not possible to calculate any accurate figures for a mill, where the new system has not yet been built, and the calculations must thus be based on the approximate figures.

	Flow m^3/d	m^3/h	BOD 5 tons/d	BOD 5 mg/l
Losses in cooking dept. losses in washing, condensates, bleaching wastes etc.	24 000	1 000	58	2 420

Temperature 20°C

BOD 5 reduction 90 %

3.2 Selection of treatment system

Pulp mill wastes with high BOD can in principle be treated with biological or chemical methods or a combination of both methods.

If the BOD is in soluble form, only low treatment efficiencis (in the order of 20 %) can be expected. If the BOD is present in suspended or colloidal form, higher efficiencis can be obtained.

A very large part of the BOD from the mill comes from the evaporation condensates. This BOD is in soluble form. Even a large part of the bleaching waste BOD is soluble.

It is therefore necessary to select a biological treatment system. A chemical flocculation would only result in removal of a minor part of the BOD. Another drawback is that very large quantities of flocculation agents (such as Alum) are needed for the bleaching wastes and that large amounts of sludge, difficult to dewater, are formed in the chemical process.

Biological methods have been used for pulp mill waste treatment for more than 15 years and several installations have been built in USA, Europe and Russia.

Biological treatment is used for the waste waters from the viscose plant in Banja Luka.

Biological treatment can be done in an activated sludge plant or with a trickling filter. As a very high efficiency is necessary, a one step treatment in a trickling filter is probably not sufficient.

Two different types of installations are proposed for treatment of the waste waters of the viscose pulp mill in Banja Luka.

The first alternative is an activated sludge plant and the second alternative is a two step installation consisting of a plastic media trickling filter followed by an activated sludge plant.

3.3 Theory of biological treatment

Biological treatment utilises the same reactions which take place during the natural self-purification process in a watercourse. The organic substances which cause the pollution are decomposed by bacteria which use the oxygen content of the water for oxidation. In this way, carbon dioxide and water are formed and new cell substance is built up. Fresh oxygen has to be added all the time either by oxygen uptake from the atmosphere or by aeration.

The action of the bacteria is wholly dependent on their enzyme systems which change the complicated organic polluting material in waste water so that it can be taken up by the cells and which, within the cells, assist in the conversion to new cell substance and oxidation products.

3.4 Sedimentation of fibres

The bleaching wastes and the white water from the wet part of the drying machine should be settled before biological treatment. This can be done in one of the existing settling tanks.

The waste water from the wet debarking should also be settled before treatment.

Sand traps and continuously cleaned bar screens must be installed before the settling tanks to remove coarse material that would affect the sludge scraping, pumping or dewatering.

The dewatering of the fibre sludge should be done with a vaccum filter. The debarking sludge can be taken to a thickener and then mixed with the bark, going to the bark press.

3.5 Mixing, neutralization and detention basin

The mixing and neutralization basin is necessary to equalise varying loads and get the best possible mixing of acid condensates and alkaline bleaching wastes. Aeration can be used for mixing. A partial stripping of SO_2 from the acid condensate can be obtained by aeration before it is mixed with the other wastes. A detention time of 4 hours is foreseen.

Detention time	h	4
Flow	m^3/h	1000
Volume	m^3	4000

In the mixing basin, neutralizing agents as CaO can be added if necessary to a pH between 6 and 8.5. Nutrients (nitrogen and phosporous compounds) also have to be added.

3.6 Selection of loadings for single step activated sludge installation or combined trickling filter - activated sludge installation

3.6.1. Activated sludge

Condensates have shown a rapid reaction both in pilot plant investigations and in full scale installations. Bleaching waste water reacts slower but the mixed waste waters can be expected to be amenable to biological treatment. It is known, however, that hardwood wastes (especially from beach) are more difficult to treat than softwood wastes.

On the basis of experiences from pilot plant test with condensates and bleaching wastes from the caustic extraction stage and full scale treatment of condensates and paper mill wastes, a unit loading of 2.0 kg BOD_5 per m^3 and day is chosen. If a mixed liquor suspended solids concentration of 7 000 mg/l is maintained, the sludge load will be about 0.3 kg BOD_5/kg sludge,day calculated on total sludge. As the sludge can be expected to have a high ash content (about 50 % as compared to about 25 % in ordinary biological sludge), the sludge load of 0.3 can be compared to a sludge load of 0.4 - 0.5 in an ordinary biological treatment plant.

As the waste waters are concentrated, the amounts oxidised per hour should be fairly high, leading to an expected efficiency of about 90 %.

3.6.2. Trickling filter and activated sludge

The treatment efficiency in a trickling filter is to a large degree dependent on the hydraulic load at low to moderate loadings.

Plastic media trickling filters have not been used for this type of pulp mill waste water. Extrapolating from experience from other types of water leads to an overall BOD load of about 4 kg/m^3,d with a recirculation factor of about 8 and a bed depth of 6,4 m (21 feet). An efficiency of at least 50 % can be expected.

The residual BOD from the trickling filter is treated in an activated sludge plant with a unit loading of 2,5 kg BOD/m^3,d and an expected efficiency of 80 %.

The overall efficiency of the two units can thus be expected to be 90 %.

3.6.3. Summary of loadings

	Alt I Act. sludge	Alt II Trickl. filter +	Act. sludge
Unit (volume) loading, kg BOD/m^3,d	2,0	4,0	2,5

3.7 Biological part. Aeration basins

After sedimentation, mixing and equilisation 58 tons of BOD are taken to the biological part. With the proposed loadings, the following aeration volumes are necessary.

	Alt I Act. sludge	Alt II Trickl. filter	+ Act. sludge
BOD, ton/d	58	58	29
Loading kg BOD/m^3,d	2,0	4,0	2,5
Aeration tank volume m^3	29 000	-	11 600
Trickling filter volume m^3	-	14 500	-
Detention time, h	25		10,5

3.8. Aeration equipment for the activated sludge unit

3.8.1. Type of aerator

The types of aeration equipment that are the most suitable for biological treatment of a pulp mill waste water in an activated sludge plant are surface turbine aerators or submerged turbine aerators with sparger rings for air distribution.

As surface turbine aerators are more economical from operation cost standpoint, this type is proposed for the plant.

In the plastic media trickling filters the aeration is obtained by natural ventilation (as in a chimney).

3.8.2. Oxygen requirements in activated sludge unit

The oxygen consumption is usually calculated on the daily BOD load.

The total oxygen consumption is calculated from the formula:

$$O_2 = a' \cdot BOD_{ox} + b' \cdot S_a$$

where

a' = oxygen consumption per unit amount of BOD oxidized.

b' = oxygen consumption per day per unit amount of sludge by endogenous respration.

BOD_{ox} = total amount of BOD oxidized per day.

S_a = total amount of sludge under aeration (dry matter).

In order to obtain a conservative figure for the oxygen consumption, the following values are choosen:

a' = 0,70
b' = 0,20

The sludge concentration has been assumed to be 7 kgs/m^3 with an organic content of 50 %.

The manufacturers of aerators guarantee the oxygenation capacity under certain standard conditions, e.g. oxygen concentration in the water 0 mg/l, temperature 10°C, aeration of clean water etc.

If the net oxygen consumption is denoted with O (Oxygen) and the necessary oxygenation capacity is called OC, the following equation is obtained:

$$OC = O \cdot \frac{C_{s(10)}}{C_{s(t)} - C_s} \cdot \frac{K_{10}}{K_t} \cdot \frac{1}{a}$$

där

$C_{s(10)}$ = saturation of oxygen at 10°C

$C_{s(t)}$ = saturation of oxygen at working temperature (20°C)

$\frac{K_{10}}{K_t}$ = ratio between the diffusion constants at 10°C and 20°C (working temp)

a = ratio between oxygen transfer coefficients in waste water and clean water

$C_{s(10)}$ = 11,3 mg/l

$C_{s(t)}$ = 9,2 mg/l at 20°C

C_s = 2,0 mg/l

$\frac{K_{10}}{K_t}$ = 0,83

a = 0,70

The following data are obtained:

		Alt 1 Act.sludge	Alt 2 Trickl. filter	+ Act.sludge
BOD-load	kg/d	58.000	-	29.000
Amount of sludge in the system	kg	~200.000		~80.000
Organic part	kg	~100.000		~40.000
Net oxygen consumption	kg/d	55.000		22.000
Gross oxygen consumption = Oxygenation capacity	kg/d	~100.000		~41.000

The oxygenation capacity has to be supplied by several aerators.

3.9. **Nutrients**

As the waste water is deficient in phosphorous- and nitrogen compounds, nutrients must be added if the treatment shall proceed with the desired speed.

Nitrogen	4 kg N per 100 kg BOD_5
Phosphorous	1 kg P per 100 kg BOD_5

This gives the following consumption of nutrients.

		Act.sludge and trickl.filter + Act.sludge
BOD	kg/d	58.000
N	kg/d	2.320
P	kg/d	580
$(NH_4)_2SO_4$	kg/d	~ 11.000
H_3PO_4 86 %	kg/d	2.130

3.10 **Sedimentation of biological sludge from activated sludge unit**

The sedimentation is designed for a surface load of 0.7 m^3/m^2h. This gives the following tank surfaces for the different alternatives.

		Alt I Act.sludge	Trickl.filter + Act.sludge	
Design flow	m^3/h	1.000	-	1.000
Sed. tank surface	m^2	1.430	-	1.430

3.11 **Return sludge pumping, activated sludge**

If a sludge concentration of 1,5 % in settled sludge is assumed and a mixed liquor suspended solids concentration of 7.000 mg/l in the aeration basin is required, the recirculation ratio in the aeration tank must be at least 90 %.

3.12 **Excess sludge**

The amount of excess sludge is difficult to calculate as there is no full scale experience is available.

Certain assumptions have thus to be made.

The following formula is used.

$$\Delta S = a \cdot BOD_{ox} - b \cdot S_a$$

where

ΔS = sludge growth in kg/d (organic part)

a = fraction of the unit amount of BOD that goes into sludge (kg organic sludge per kg BOD).

b = fraction of the unit amount of sludge that is oxidized by endogenous respiration.

The following values for the constants are chosen:

a = 0,60
b = 0,15

The sludge production in the trickling filter is estimated to 2/3 of the production in an activated sludge unit oxidizing the same amount of BOD.

The sludge concentration in the aeration basin has been assumed to be 7 kg/m^3 with an organic content of 50 %.

		Alt 1	Alt 2	
		Act.sludge	Trickl. filter	+ Act.sludge
BOD-load	kg/d	58.000	58.000	29.000
Amount of sludge in the system	kg	~200.000	-	80.000
Organic part	kg	100.000	-	40.000
Sludge growth (org.)	kg/d	15.000	-	6.000
Sludge growth (total)	kg/d	30.000	11.000	12.000

3.13. Thickeners for biological sludge

The thickeners are designed for a material load of 40 kgs/m^{2}d. This gives the following thickener surfaces for the different alternatives.

		Alt 1	Alt 2	
		Act.sludge	Trickl. filter	+ Act.sludge
Sludge flow (dry matter)	kg/d	30.000		23.000
Spec. load	kg/m^{2}d	40		30
Thickener surface	m^2	750		750

4. Sludge treatment

The biological sludge should be dewatered and dumped or burnt together with wood refuse.

The dewatering can be done in decanter centrifuges after thickening.

		Alt 1 Act.sludge	Alt 2 Trickl. filter + Act.sludge
Amount of sludge (dry matter)	kg/d	30.000	23.000
Amount of sludge 3 %	m^3/d	1.000	770
Dewatering capacity at 20 h/d working time	m^3/d	50	~40
Number of centrifuges (20 m^3/h)	-	3	2 à 3
Amount of sludge 18 %	m^3/d	170	~130

5. Technical description of treatment plant

5.1 Mixing tank

The different waste waters from the cellulose factory shall be collected in a mixing tank. At the inlet lime is added for neutralisation. For this purpose flow and pH control for the different waste waters are needed. The water flow and pH value shall be registrered in the control central.

Lime will be kept in a silo with a suitable volume, i.e. 100 m^3.

The silo will be equipped for a reliable dosing function. The tenderers suggest equipment and specify characteristic data.

Furthermore will $(NH_4)_2SO_4$ be added as well as H_3PO_4 for supplementing the water to accurate conditions for a biological process. The tenderer suggest the equipment and design. Tanks should be suitable for keeping the chemicals. Monopumps or membran pumps should be used for dosage.

To achieve an acceptable mixing, feeding and neutralisation of the different waste waters the mixing tank shall consist of several tanks linked together. The fifth chamber shall be designed for use as grit chamber.

Air will be added at the tank bottom.

The necessary air compressors will be placed in a separate building.

In the far end of the mixing tank will a pumping station be placed. The pumps shall be designed differently for alternativ 1 and alternative 2.

Alt 1. 4 pumps each of 300 m^3/h x 5 m.

Alt 2. 4 pumps each of 300 m^3/h x 12 m.

The mixing tank shall be equipped with a length 10 m weir for emergency use.

5.2 Trickling filters

For alt 2, the waste water shall be treated in trickling filters.

The filter volume needed is about 14 800 m^3, disposed on four filters each with a diameter of 26,0 m and a working deepth of 7,0 m.

The filter material will be choosen by the tenderer. The design is based on a plastic media.

To reach an accurate hydraulic load it is necessary to recycle the water 8-9 times.

Therefore a pumping station for this purpose is needed. At least 6 pumps are needed. Each pump shall have a capacity of 2000 m^3/h x 12 m.

The water from the filter is collected in the filter bottom and channeled to the pumping station.

The "excess flow" = 1000 m^3/h passes on to the aeration basins.

5.3 Aeration basins

The basins for aeration will treat the waste water either from the mixing tank (alt 1) or from the trickling filters (alt 2).

The basins shall be given a suitable design to ensure an efficient aeration of the water and a good mixing of the return sludge with the water.

For aeration surface aerators will probably be suitable.

The oxygen capacity needed for alt 1 is 100.000 kg O_2/d. The capacity could for instance be produced by 70 surface aerators each with 65 kg O_2/h.

In alt 2 the needed capacity is 41 000 kg O_2/d, which could be produced by 28 surface aerators.

The aeration basins and the settling basins can be built in a compact block. Each basin should have the same shape, 70,0 x 10,0 x 5,0 m.

The tenderer is free to offer an alternative design for the aeration system.

5.4 Sedimentation basins

The water sludge mixture from the aeration basins will be lead to two sedimentation basins. Each basin shall be equipped with a pump for return sludge placed on a double traverse. Each pump shall have a capacity of at least 900 m^3/h x 4 m. A centrifugal pump with a Wemco wheel would be suitable for return sludge pumping.

For the excess sludge is needed at least 4 pumps. The capacity shall be 20-100 m^3/h x 10 m.

Monopumps would be suitable for this purpose.

The return sludge will be collected in open channels and lead to the aeration basins.

In the same way the treated water will be collected in open channels and lead to the outlet.

The weirs shall have a length exceeding 60 m.

5.5 Sludge thickeners

The excess sludge will be pumped to two sludge thickeners. The thickeners shall be designed for a continous process.

The sludge inlet shall be in the center just under the surface, and the outlet in the bottom.

For an efficient thickening process a slow speed mixer is needed.

The overflow weirs for water will be placed at the periphery.

5.6 Sludge dewatering system

Sludge from the thickeners will be dewatered with i.e. decanter centrifuges. Hereby the sludge will increase its concentration of dry solids from 3 % to at least 18 %.

For this purpose a dewatering capacity of 40-50 m^3/h is needed.

The capacity is proposed to be desposed as follows:

3 centrifuges on each 16-20 m^3/h with 20 h operating time/d. For feeding the centrifuges, monopumps shall be used with a variable capacity of 5-25 m^3/h. 4 pumps are needed to ensure a continous process.

For polyelectrolyte dosage a tank of 200 m^3 is needed. A special room for handling and keeping these chemicals is needed.

Dosage pumps for the chemicals shall be monopumps. The capacity should be suggested by the tenderer.

For transportation of dewatered sludge a system of conveyor belts or screws is suitable. The transportation capacity shall exceed 15 m^3/h.

5.7 Piping systems

The different waste waters to be treated shall be led separatly from the different departments to a sewer leading to the mixing tank. The waste waters must be separated from fibers before they are discharged into the sewer leading to the mixing tank.

To avoid shock loads on the treatment plant from spills during unnormal conditions in the mill, spill tanks should be built in the different departments. The spill tanks should be equipped with pumps for return of the concentrated wastes to the internal recovery system.

All the pipes shall be made of acid proof material, i.e. polyester or polyetene.

The water velocity in the pipes and the channels must not exceed approximately 1.0 m/see and not be less than 0,6 m/s.

Equipment for measuring the different flows before the water is led into the mixing tank shall be installed.

5.8 General construction criterias

All the basins shall be built of waterproof concrete. The mixing tank shall be treated against corrosion.

The level of the treatment plant shall be proposed by the tenderers. The HHL in the river Urbas is +153,00.

Automation

The plant shall have an automatic equipment that makes it possible to control the whole process from the control central. The different parts of the process shall be controlled by different parameters such as:

Lime dose will follow the pH value in the first mixing chamber.

The dose of phosphours acid and ammoniasulphate will be proportional to the waste water flow.

The waste water pumps will start and stop for different levels in the mixing tank. The air compressors for the mixing tank will switch at certain time intervalls. The surface aerators can be equipped for two different capacities and change capacity according to the oxygen level.

The sludge pumping from the sedimentation basins shall be more frequent in the inlet half of the basins and less frequent in the outlet half of the basins.

The sludge pumping will work continously. The excess sludge pumps will also work continously. The capacity shall be changed from the control central.

The sludge dewatering system shall operate without a continous manual control.

6. International tendering

In this report are given the basic data for the treatment plant as they are known at present. These are to be regarded as general conditions for design and operating criteria.

In chapter 5, more specific technical and operating criteria are formulated. Before an international tendering can take place the basic data must be confirmed and related to the actual conditions in the enlarged pulp mill.

For the tendering it is suggested that "Conditions of contract for works of civil engineering construction" second edition is used in pertinent parts.

7. Summary of basic data

		Alt 1 Act.sludge	Alt 2 Trickl. filter	Alt 2 + act.sludge
Treatment efficiency	%	90	50	80
Volume loading	kg/m^3d	2,0	4,0	2,5
Amount of BOD	ton/d	58	58	29
Waste flow	m^3/h	1 000	1 000	1 000
Mixing tank	m^3	4 000	4 000	-
Trickling filter	m^3		14 500	-
Aeration basin	m^3	29 000	-	11 600
Net oxygen demand	kg/d	55 000	-	22 000
Nominal oxygenation capacity	kg/d	100 000	-	41 000
Nutrients				
$(NH_4)_2 SO_4$	kg/d	11 000	11 000	-
H_3PO_4 (86 %)	kg/d	2 130	2 130	-
Neutralization agents	kg/d	15 000	15 000	-
Sedimentation basin	m^2	1 430	-	1 430
Recirculation ratio	%	90	800	90
Excess sludge	kg/d	30 000	-	23 000
Thickener	m^2	750	-	750
Sludge volume 3,0 %	m^3/d	1 000	-	770
Centrifuges à 20 m^3/h	no	3	-	3
Sludge volume 18 %	m^3	170	-	130

8. Cost calculations

8.1. Investment costs (Skr · 10^3)

	Alt 1	Alt 2
Pumping stations and tubes system	2 500	3 500
Neutralisation and mixing tank	1 500	1 500
Dosage equipment	400	400
Aerator basins including surface aerators	12 000	5 500
Trickling filters	-	8 000
Sedimentation basins	1 500	1 500
Sludge thickeners	750	750
Sludge dewatering	2 000	2 000
Control central	150	150
Electric installations and equipment for instrumentation	2 500	2 500
Planning, administration final design	2 000	2 000
Total investment	25 300	27 800

8.2 **Annual costs** (Skr · 10^3)

Operating costs	Alt 1	Alt 2
Maintainance (2,5 % inv.)	660	670
Electric power (à 0,6 Skr/kWh)	1 600	1 700
Lime (à 60 Skr/ton)	330	330
$(NH_4)_2 SO_4$ (à 300 Skr/ton)	1 200	1 200
H_3PO_4 (à 2 400 Skr/ton)	1 850	1 850
Polyelectrolytes (à 18 Skr/kg)	500	380
Transportation, sludge (à 75 kr/ton)	420	320
Employers	80	80
	6 640	6 530
Investment costs		
16,3 % of inv.	4 260	4 530
Total annual costs	10 900	11 060

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Jan Rennerfelt   Stig Norling

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