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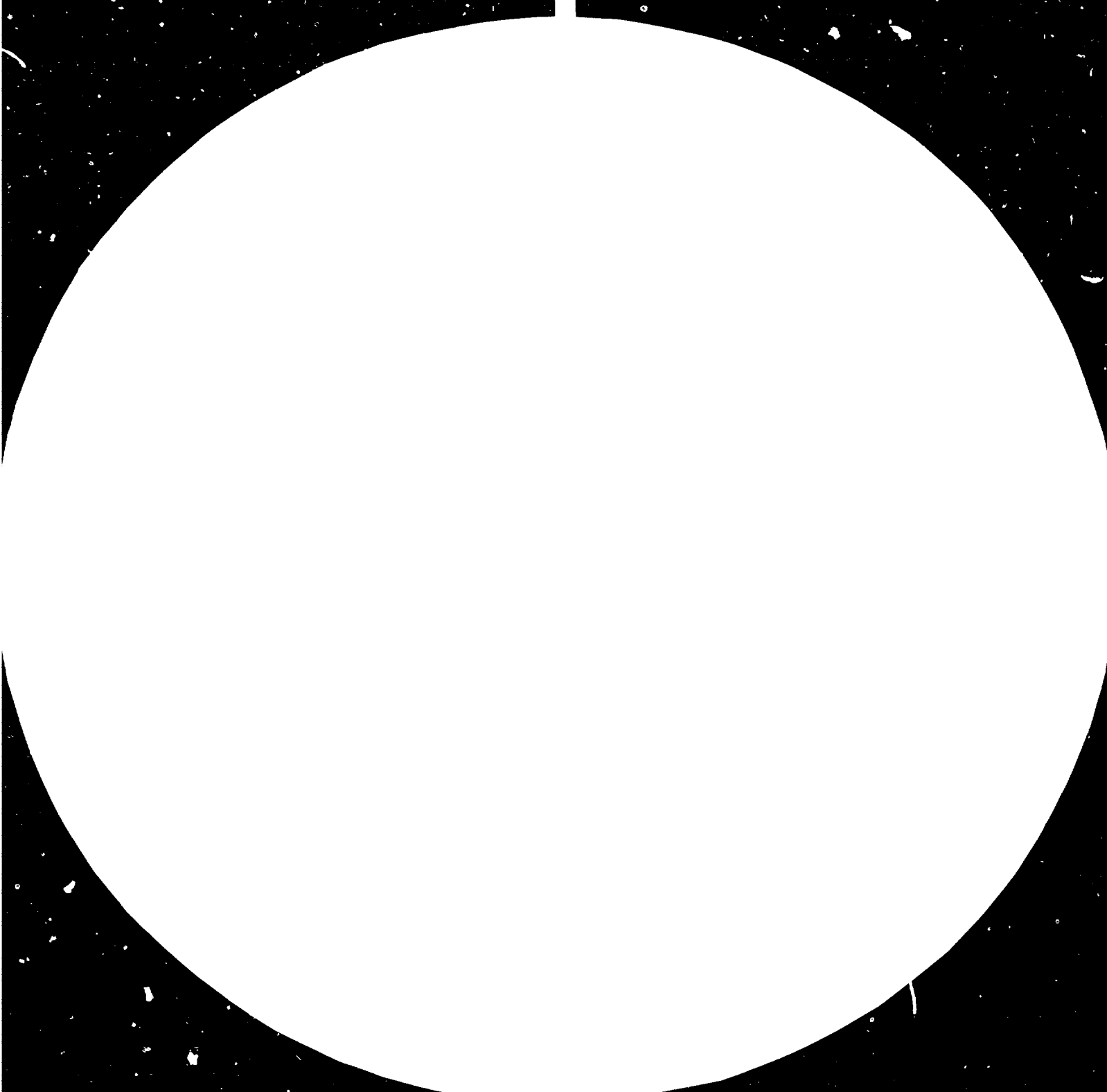

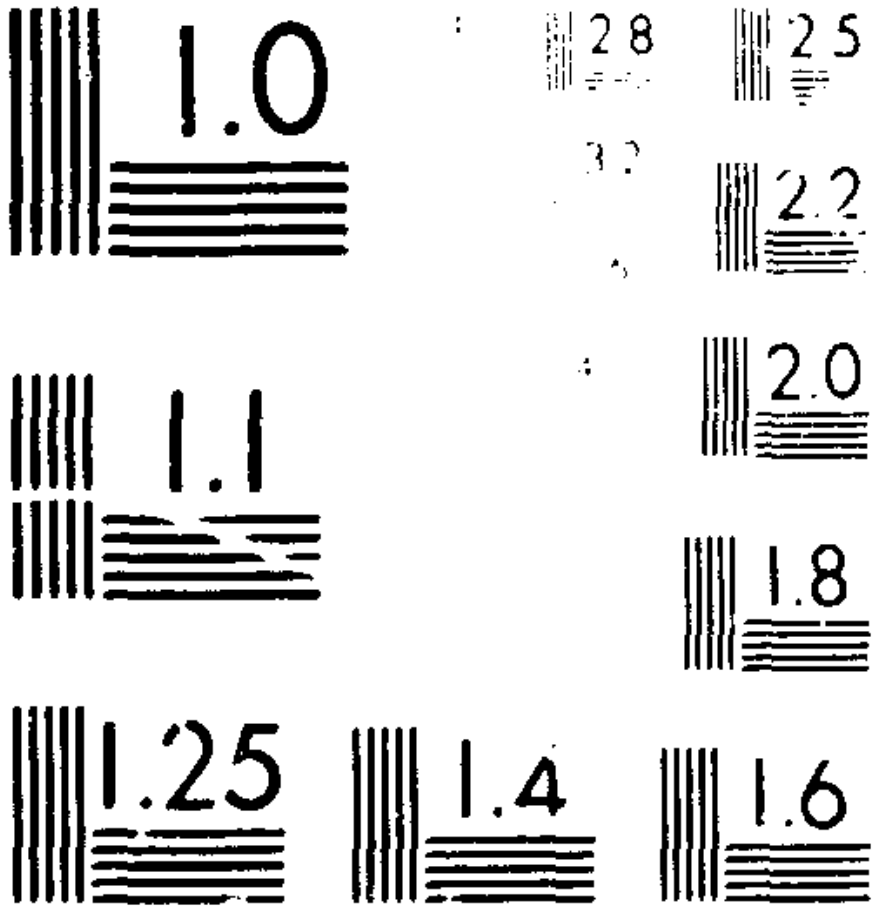
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CHEMIE LINZ AG

Unser Zeichen	Bearbeiter	Hausruf	Tag
			IVL

Empfänger (Durchschläge an)

10636

Pro.Nr. US/INT/81/071

Report on Activities of 4. UNIDO-Workshop on Fertilizer Plant Maintenance

Place of training: CHEMIE LINZ AG, Linz, Austria
Period of training: May 11 to June 26, 1981
Participants:

Mr. Md. Mansur Rahman/Bangladesh
Mr. A.U. Mohammed Zubair/Bangladesh
Mr. Yang Zhichao/People Rep. of China
Mr. Dessoki R. Ramadan/Egypt
Mr. Prem Kumar/India
Mr. Johannes Pudjiharto/Indonesia
Mr. Mursidi Kasdipranoto/Indonesia
Mr. J.A.M. Silva Costa/Portugal
Mr. A.M. Ferreira/Portugal
Mr. A. Hassib El-Asmar/Syria
Mr. Murat Ercan/Turkey
Mr. Rifat Günebakan/Turkey

Training programme:

1st week: May 11 - May 15,1981

Opening of fourth workshop by Mr. C. Keleti, general information on Chemie Linz, workshopprogramme, instructions on safety measures, fundamentals of maintenance, spare parts system.

2nd week: May 18 - May 23,1981

The training took place in the technical section of the ammonia dept., central workshop, electrical-

./2

and instrument dept. The team was split up into several groups. Study visit to peat producing plant near Salzburg.

3rd week: May 25 - May 29,1981

Activities were set in the technical dept. for water supply, gas reforming, air separation, urea and melamine production, central workshop and material testing dept.

4th week: June 1 - June 6,1981

During this week lectures and practical work took place in technical dept. for nitric acid, calcium ammonium nitrate, ammonium sulphate, sulphuric acid, compound fertilizer, cement, phosphoric acid, single super phosphate and central workshop, as well as water supply and gas reforming. Study visit to hydro electric power station on the Danube.

5th week: June 9 - June 13,1981

Training activities centred on lectures in measurement and controll dept., central workshop, nitric acid, ammonium sulphat, sulphuric acid and compound fertilizer plants, heavy duty bag production facilities. Study visit to maintenance section of petrochemical plant in Vienna.

Inspection of heavy equipment division of Voest Alpine.

6th week: June 15 - June 19,1981

In the departmens for civil works, engineering and design, material testing, instrumentation, boiler inspection and safety valve repair, training institute, electrical maintenance, nitric acid, sulphuric acid and ammonia production.

./3

7th week: June 22 - June 26,1981

The final week was spent in water supply, gas reforming, cooling water plant, material testing dept., instrumentation, electrical workshop. Seminars were provided on cost controll, pollution controll and refractory lining. Study visit to maintenance section of acrylo nitrile plant in Enns and to bearing manufacturing works in Steyr.

UNIDO - WORKSHOP 1984 - PROGRAMME

WEEK	ATH	ATG	ATN	ATP	BTH	THW	TEL	TME	TMP
	AMMONIA	WATER SUPPLY GAS-REFORMING, OXYGEN	CAN, AN, AS NITRIC ACID, BAG PROD.	H_2SO_4, NPK, CEMENT, H_3PO_4, SSP	UREA MELAMIN	CENTRAL WORK-SHOP	ELECTRICAL DEPT.	INSTRUMENT DEPT.	MATERIAL TESTING
11.5. - 15.5.	----	GENERAL INFORMATIONS							
16.5. - 22.5.	1,5,6,7					2,9,10,12	3,4,8,11	3,4,8,11	
23.5. - 29.5. (29.5. FREE)		2,10			4,5 / 2,10	1,3,8,11			6,7,9,12
30.5. - 6.6.		4,5,6,7	2,9,10,12	1,5,6,7		3,8,11 / 1 4			
7.6. - 12.6. (7.6. FREE)			1,3,11 / 5	2,4,8,9,10		6,7 / 5		12	
13.6. - 19.6. (13.6. FREE)	3 / 4,10 5		4,8,7	2,9 / 8 10				6,12	1,11 / 5,7
20.6. - 26.6.		1,11					6,12 / 9,10 5,7	5,7 9,10	2,3,4,8

PARTICIPANTS:

1	MR. RAHMAN	BANGLADESH	M
2	MR. ZAHEER	— " —	M
3	MR. YANG	CHINA	M
4	MR. RAMADAN	EGYPT	M
5	MR. KUMAR	INDIA	M
6	MR. MURSIDI	INDONESIA	M
7	MR. RUDIJARTO	— " —	M
8	MR. SILVA COSTA	PORTUGAL	M
9	MR. FERREIRA	— " —	M
10	MR. EL-ASHAR	SYRIA	M
11	MR. ERCAN	TURKEY	M
12	MR. GÜNEŞAKAN	— " —	M

GENERAL MEETINGS:

13.5.	8⁴⁵ - 12⁰⁰	US SAFETY
	13³⁰ - 16³⁰	TBW CIVIL DEPT.
20.5.	8⁴⁵ - 12⁰⁰	TME INSTRUMENT DEPT.
	13³⁰ - 16³⁰	TMP MATERIAL TESTING
27.5.	8⁴⁵ - 12⁰⁰	TEL ELECTRICAL DEPT.
	13³⁰ - 16³⁰	THW CENTRAL WORKSHOP
4.6.	8⁴⁵ - 11¹⁵	TCB DESIGN
	11³⁰ - 12³⁰	UNIDO SERVICE
	14⁰⁰ - 15⁰⁰	UNIDO INVESTMENT PROMOTION
	15⁰⁰ - 16³⁰	GBR WORKS COUNCIL
11.6.	9⁰⁰ - 11³⁰	REINZ MATERIALS FOR GASKETS
11.6.	8¹⁵ - 10¹⁵	TKB DESIGN
	10³⁰ - 12³⁰	TBW CIVIL DEPT.

24.6. 9⁰⁰-11⁰⁰ E COST CONTROL
11¹⁵-12¹⁵ UNIDO-FINANCE
14⁰⁰-16⁰⁰ UNIDO PROMOTION

VISITS TO OTHER COMPANIES

23.5. HEAT TREAT FÜRNROS
6.6. HYDROELECTRIC POWER STATION AHLDORF
12.6. VÖEST - LINZ
13.6. VOEST - SCHWECHAT
14.6. FIAT - TURIN (TURIN)
OTTICINE - TURIN (MASSA)
24.6. FIAT
STEYR

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: [illegible]
Nationality: Bangladesh

(1)

Project: UNIDO-Workshop

May Date	Dept.	Aktivities	Signature CL
10.		ARRIVAL IN VIENNA, ATTENDED BY CL	
11.		OPENING OF THE UNIDO WORKSHOP INTRODUCTION TO CL MANAGER	
12.		WORKSHOP PROGRAMME, ORGANISATION OF CL	
13.		INSPECTION OF SAFETY MEASURES, DISCUSSION WITH CIVIL DEPARTMENT	
14.		FUNDAMENTALS OF MAINTENANCE, SPARE PARTS SYSTEM AT CL	
15.		~~FURTHER~~ ORGANISATION OF CL, VISIT TO MAINTENANCE DEPARTMENT ATH	
16.		HOLIDAY	
17.		HOLIDAY	
18.	ATH	~~GENERAL~~ DISCUSSION REGARDING ~~THE~~ ORGANIZATION OF DEPT, PLANT. VISIT TO OLD AMMONIA PLANT, ALL MAGAZINE ~~WAS~~ UNDER THE DEPTT. DISCUSSION ON VARIOUS PROBLEMS	
19.	"	DISCUSSION ON SINGLE TRAIN AMMONIA PLANT. VISIT TO SINGLE TRAIN UNIT. DISCUSSION ON VARIOUS PROBLEMS	
20.	TME/THP	~~GENERAL~~ DISCUSSION WITH INSTRUMENT DEPT. GENERAL DISCUSSION WITH MATERIAL TESTING DEPT.	
21.	~~TEP~~ ATH	~~GENERAL DISCUSSION WITH MATERIAL TESTING DEPT.~~ DISCUSSION ON VARIOUS PROBLEMS FACED BY THE PARTICIPANTS IN THEIR PLANT	
22.	ATH	DISCUSSION ON VARIOUS PROBLEMS IN CONNECTION OF PLANT	
23.	GENERAL	VISIST TO PEAT PLANT ~~NEAR~~ OF CHEMIE LINZ NEAR SALZBURG. VISIT TO SALZBURG	
24.		HOLIDAY	
25.	THW	DISCUSSION ON ORGANIZATION OF DEPT. VISIT TO WORKSHOP. D	
26.	"	VISIT TO MAIN CENTRAL WORKSHOP, DISCUSSION ON VARIOUS WORK PERFORMED. VISIT TO CENTRAL WORKSHOP	
27.	TEL	GENERAL DISCUSSION WITH ELECT DEPT. VISIT TO ELECTRICAL WORKSHOP, DISCUSSION ON BALANCING	
28.	~~TEL~~	HOLIDAY	
29.	THW	DISCUSSION ON VARIOUS METHOD USED IN REPAIRING VARIOUS EQUIPMENTS, VISIT TO ALL MAGAZINES OF CENTRAL WORKSHOP	
30.		HOLIDAY	
31.		HOLIDAY.	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr.Md.M. Rahman
Nationality: Bangladesh.

Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature Cl
1e 1	THN.	OBSERING THE LIFTING 65T VASSEL. REPAIR WORK OF DRYER OF ATP DEPT. PERFORMED BY THW DEPT. VISIT TO ALL MAGAZINE OF THW INCLUDING CIVIL DEPT	
2	THW	STUDYING AT THE CENTRAL WORKSHOP	
3	THW	STUDYING ATEM THE CENTRL WORKSHOP	
4	GENERAL	MEETING WITH DESIGN DEPT. MEETING WITH UNIDO PERSONNEL. MEETING WITH STORE & CONTROL	
5	THW	VISUALIZED HEAT EXCHANGER WELDING, Repairing pumps & Compressors	
6	GENERAL	EXCURSION TO HYDRO ELECTRIC POWER STATION AT ARWINDEN.	
7		HOLIDAY	
8		HOLIDAY	
9	ATN	ATTENDED AT THE ATN DEPT, VISITED HNO_3 PLANT & AM BAG MANUFACTURING UNITS	
10	ATN	ATTENDED AT THE ATN DEPT, VISITED AN PLANT.	
11	ATN	ATTENDED ATN DEPT. VISUALIZED REPAIRING [illegible]	
12	GENERAL	[illegible] TO VISIT ALPINE / LINZ	
13	GENERAL	VISIT TO PETRO CHEMIE / LINZ	
14		HOLIDAY	
15	TMP	[illegible]	
16	TMP	[illegible]	
17	GENERAL	[illegible]	
18		HOLIDAY	
19	TMP	[illegible]	
20		HOLIDAY	
21		HOLIDAY	
22	ATN	[illegible]	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr.Md.M. Rahman
Nationality: Bangladeshi

81 Project: UNIDO-Workshop

te	Dept.	Aktivities	Signature Cl.
ne 23	ATC	[illegible]	
24	GENERAL	[illegible]	
25	"	[illegible]	
26	"	[illegible]	
27			

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: A [illegible] FURKAN
Nationality: BANGLADESH

Project: UNIDO-Workshop

May Date	Dept.	Aktivities	Signature CL
10.	GENERAL	ARRIVAL ✈ VIENNA, ATTENDED BY CL	
11.	"	OPENING OF CHE 4TH WORKSHOP. INTRODUCTION TO CL-MANAGER	
12.	"	WORKSHOP PROGRAMME, ORGANISATION OF CL	
13.	"	INSTRUCTIONS ON SAFETY MEASURES. DISCUSSION WITH CIVIL DEPARTMENT	
14.	"	FUNDAMENTALS OF MAINTENANCE, SPARE PARTS SYSTEM OF CL	
15.	"	REPAIR ORGANISATION OF CL. VISIT TO MAINTENANCE DEPARTMENT ATP	
16.		HOLIDAY	
17.		HOLIDAY	
18.	THW	INTRODUCTION AT CENTRAL WORKSHOP. DISCUSSED WITH HEAD OF CENTRAL WORKSHOP ABOUT ORGANISATION	
19.	THW	DISCUSSED ABOUT OPERATING ASPECTS, GUIDELINES FOR NEW PROJECTS, VISITED DIFFERENT SECTIONS OF CENTRAL WORKSHOP	
20.	THE/TMP	DISCUSSION WITH INDUSTRIAL DEPTT. & NATIONAL TIMES ARTICLE ABOUT ORGANISATION OF THE CENTRAL WORKSHOP	THE
21.	THW	OBSERVED SOME WORKING PROCEDURES, REPAIRING, MAINTENANCE OF COMPRESSOR, PUMP, GEAR BOX, VISIT TO CENTRAL WORKSHOP	
22.	THW	OBSERVED MANUFACTURING OF HEAT EXCHANGER, VISIT TO ENGINEERING SCHOOL, TALKED TO THE TRAINING DEPTT.	
23.	GENERAL	EXCURSION TO PAPER PLANT OF CL, NEAR SALZBURG.	
24.		HOLIDAY	
25.	BTH	DISCUSSION WITH IDEA-MAINTENANCE PLANTS MAINTENANCE HEAD ABOUT ORGANISATION, PLANNING OF MAINTENANCE WORKS, SCHEDULES	
26.	BTH/ATG	VISIT TO IDEA "MAINTENANCE PLANTS, STUDIED OPERATIONS. VISIT TO WATER/GAS/O/N/NH GROUP, DISCUSSED ORGANISATION	
27.	TEL/THW	DISCUSSION WITH ELECTRICAL DEPTT. VISIT TO E-WS, STUDIED OPERATION & PLANNING OF, DISCUSSION WITH PRODUCTION HEAD OF CENTRAL WORKSHOP	
28.		HOLIDAY	
29.	ATG	VISIT TO THE JOINT EXPERTS & DIFFERENT GAS PLANTS, TALK ATG DEPTT. TALKED ABOUT ORGANISATION, OPERATIONS	
30.		HOLIDAY	
31.		HOLIDAY	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1991
Name: Mr. A.U.M. Zubair
Nationality: Bangladesh

Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature Cl.
ıe 1	ATN	[illegible]	
2	ATN	[illegible]	
3	ATN	[illegible]	
4	TKB	[illegible]	
5	ATN	VISIT TO LAN. CASTING SHOP OF ATN.	
6	GENERAL	EXCURSION TO HYDROELECTRIC POWER STATION AT ALBRUNDEN	
7		HOLIDAY	
8		HOLIDAY	
9	ATP	[illegible]	
10	ATP	[illegible]	
11	GENERAL/ATP	[illegible]	
12		VISIT TO VOEST ALPINE AT LINZ	
13		VISIT TO PETROCHEMIE AT VIENNA.	
14		HOLIDAY	
15	ATP	[illegible]	
16	ATP	[illegible]	
17	GENERAL	MEETING WITH CIVIL & DESIGN DEPTT. VISIT TO EBG & OCHSNER.	
18		HOLIDAY	
19	ATP	DISCUSSION ABOUT CORROSION, EROSION & WEAR IN ATP PLANTS	
20		HOLIDAY	
21		HOLIDAY	
22	TMP	VISIT TO MATERIAL TESTING DEPTT. DISCUSSIONS.	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. A.U.M. Zubair
Nationality: Bangladesh

81 Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature Cl.
ne 23	TMP	~~visit~~ SIZE SIZE EQUIPMENT & MATERIAL TESTING PROCEDURES.	
24	GENERAL	VISIT TO ACRYLONITRYL PLANT ENKA AND BLADING MANUFACTURE AT SIEVE.	
25	"	COST CONTROL . FINAL MEETING WITH UNIDO . POLLUTION CONTROL	
26	"	FINAL DISCUSSIONS REGARDING MAINTENANCE .	
27			

A. U. M. Zubair

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: YANG ZHI-CHAO
Nationality: CHINA

Project: UNIDO-Workshop

May Date	Dept.	Aktivities	Signature CL
10.			
11.			
12.		Take Leave from Beijing	
13.		Arrival in Linz	
14.		Fundamentals of maintenance - spare parts system of CL	
15.		Repair organisation of CL, visit to maintenance department ATP	
16.		Holiday	
17.		Holiday	
18.		Studying at instrumentation department	
19.		Studying at instrumentation department	
20.		Meeting with instrumentation department and material test depart.	
21.		Studying at electrical department	
22.		Studying at electrical department	
23.		Excursion to coal plant of CL near Salzburg	
24.		Holiday	
25.		Studying at central workshop	
26.		Studying at central workshop	
27.		Meeting with central workshop and electrical depart.	
28.		Folk festival of Austria	
29.		Studying at central workshop	
30.		Holiday "	
31.		Holiday	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. Z. Yang
Nationality: China

Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature CL
ıe 1		Studying at the central workshop	
2		Studying at the central workshop	
3		Studying at the central workshop	
4		Meeting with owner and investment question	
5		Studying at the central workshop	
6		Visiting Hydro-power station	
7		Holiday	
8		Holiday	
9		Studying at the ATH Department	
10		Studying at the ATH Department	
11		Studying at the ATH Department	
12		Visit to the VEST Alpine / LINZ	
13		Visit to the Petrochemie Plant Linz	
14		Holiday	
15		Studying at the ATH Department	
16		Studying at the ATH Department	
17		Studying at the ATH Department	
18		Holiday	
19		Studying at the ATH Department	
20		Holiday	
21		Holiday	
22		Visiting and Technical testing department	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. Z. Yang
Nationality: China

81 Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature CL
ne 23		Training in the relevant fields of chemistry	
24		[illegible]	
25		Test writing. Final meeting with UNIDO and plant for control.	
26		Final discussion + preparing the travel	
27			

CHEMIE LINZ AG
TVL

RECORD OF WORKING TIME

Month: May 1981
Name: Mr. D.R. Ramadan
Nationality: Egypt

981 Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature CL
ıy 10		ARRIAVAL IN VIENNA. HITCHTED BY C.L.	
11		OPEINING of THE 1. WORKSHOP, INTRODUCTION TO CL MANAGER	
12		WORKSHOP PROGRAMME, ORGANISATION of CL	
13		INSTRUCTIONS ON SAFETY MAISURES, DISCUSSION WITH CIVIL DEPA.	
14		FUNDAMENTALS of MAINTENANCE, SPARE PARTS SYSTEM of CL	
15		REPAIR ORGANISATION of CL, VISIT TO MAINTENANCE dept. NTP	
16	x	HOLIDAY	
17	x	HOLIDAY	
18		STUDYING TME INSTRUMENT DEPA.	
19		STUDYING at INSTRUMENT DEPA.	
20		MEETING WITH INSTRUMENT DEPA. AND MATERIAL TESTING.	
21		STUDYING at (TEL) ELECTRICAL DEPA.	
22		" " " "	
23		EXCURSION TO PEATPLANT of CL NEAR SALZBURG.	
24	x	HOLIDAY	
25		STUDYING at (BTH) UREA & MELAMIN PLANT.	
26		" " " "	
27		MEETING WITH (TEL) AND CENTRAL WORKSHOPS. (THW)	
28		FOLK FESTIVEL of AUSTEA.	
29		STUDYING at (BTH) UREA plant	
30		HOLIDAY	
31		HOLIDAY.	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. D.R. Ramadan
Nationality: Egypt

31 Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature Cl.
ie 1	ATE	Studying at (ATE) Water Supply - Gas - Reforming	
2	ATE	" " " " and Oxygen	
3	^	Studying at (TMW) Central workshop.	
4		Meeting with (TKB) and UNIDO & Co-operation Council	
5		Studying at (ATG) Central workshop.	
6		~~Holiday~~ studying at Power station HYDR. ABSORBER	
7	X	" Holiday	
8	X	" "	
9		Studying at (ATP) H_2SO_4, WPK, CEMENT, H_3PO_4, SP	
10		Studying at (ATP) " " " " " "	
11		Meeting Material of GASKETS and (ATP)	
12		VISIT TO LENZ ALPINE / LINZ	
13		VISIT TO PETROCHEMIE / LINZ-MAIA	
14	X	Holiday	
15		Studying at (ATH) AMMONIA Plant.	
16		" " " " and (A.TN) COMPANY	
17		Meeting (TKB) Design & CIVIL Dept. visit to EBG, ESCHBACH (LINZ)	
18	X	Holiday	
19		Studying at (ATN) nitric ACID & BAG Plant.	
20	X	Holiday	
21	X	Holiday	
22		Studying at (TMP) Material testing	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. D.R. Ramadan
Nationality: Egypt

81 Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature Cl.
ne 23		Studying at (TMP) Material testing	
24		Visit to (Linz) and steyr (BEARing manufacturing steyr	
25		Meeting with Contact with Austrian Part - UNIDO	
26		Final Discussions Regarding assistance	
27			
		Ramadan 25/6/1981	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: PREM KUMAR
Nationality: INDIAN

Project: UNIDO-Workshop

day Date	Dept.	Aktivities	Signature CL
10.	GENL	ARRIVAL IN VIENNA. ATTENDED BY CHEMIE LINZ	
11.	"	OPENING OF FOURTH WORKSHOP. INTRODUCTION TO CL MANAGERS	
12.	"	WORKSHOP PROGRAMME, ORGANISATION OF CL	
13.	"	INSTRUCTIONS ON SAFETY MEASURES, DISCUSSIONS WITH CIVIL DEPTT	
14.	"	FUNDAMENTALS OF MAINTENANCE, SPARE PARTS SYSTEM OF CL	
15.	"	REPAIR ORGANISATION OF CHEMIE LINZ - VISIT TO MAINT. DEPTT ATH	
16.	X	HOLIDAY	
17.	X	HOLIDAY	
18.	ATH	INTRODUCTION OF DEPTT. BY MR. FASCHINGER - VISIT TO COMPRESSOR HOUSE	
19.	ATH	DISCUSSIONS REG. MAINT. PROBLEMS OF COMPRESSORS - VISIT TO OLD AMMONIA PLANT	
20.	TME+TMP	LECTURE BY INSTRUMENT and MATERIAL TESTING DEPTTS	
21.	ATH	DISCUSSIONS REG. CENTRIFUGAL COMPRESSOR + PUMPS - VISIT TO SINGLE TRAIN UNIT	
22.	ATH	TECH. DISCUSSIONS REG PROBLEMS + ADMINISTRATION OF DEPTT ATH	
23.	GENL	EXCURSION TO PEAT PLANT OF CL. NEAR SALZBURG	
24.	X	HOLIDAY	
25.	BTH	INTRODUCTION OF UREA PLANT + VISIT TO UREA PLANT + STORAGE	
26.	BTH	INTRODUCTION AND VISIT OF MELAMINE PLANT	
27.	TEL+THW	LECTURES REG. ELECT. + CENTRAL WORKSHOP DEPTTS ALSO VISIT TO ELECT. WORKSHOP for BALANCING MI	
28.	X	HOLIDAY	
29.	BTH	DISCUSSIONS REG. UREA SCRAPER - VISIT TO UREA STORAGE + BAGGING	
30.	X	HOLIDAY	
31.	X	HOLIDAY	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. P. Kumar
Nationality: India

31 Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature CL
ıe 1	ATG	INTRODUCTION OF DEPTT. VISIT TO WATER WORKS + BOILER FEED WATER PLANT	
2	ATG	VISIT TO STEAM REFORMING + GAS DIVIDING PLANTS DISCUSSIONS OF PROBLEMS	
3	ATP	INTRODUCTION VISIT AND TECH. DISCUSSIONS ABOUT H_2SO_4 + NPK PLANTS + CEMENT PLANT	
4	GENL	MEETING WITH DESIGN DEPTT, UNIDO REVIEW MEETING WITH WORKS COUNCIL	
5	ATP	INTRODUCTION, VISIT AND TECH. DISCUSSIONS REG. SUPER PHOSPHATE, H_3PO_4	
6		EXCURSION TO ARWINDEN ASTEN HYDROELECTRIC PLANT RAW MAT STORAGE FERTILIZER BAGGING	
7		HOLIDAY	
8		HOLIDAY	
9	ATN	VISIT TO AND TECH. DISCUSSIONS REG. NITRICACID + BAG PROD	
10	ATN+THW	VISIT + TECH. DISCUSSIONS REG. CAN PLANT. VISIT TO TRNG SCHOOL + WORK SHOPS. PLANTS	
11	THW	SYMPOSIUM REG. REINZ-DICHTUNGS-GMBH + DISCUSSIONS REG. CENT. WORKSHOPS	
12	GENL	VISIT TO VOEST ALPINE WORKS AT LINZ	
13	GENL	VISIT TO PETROCHEMIE SCHWECHAT + EXCURSION TO VIENNA.	
14		HOLIDAY	
15	TMP	TECH. DISCUSSIONS REG. MECH. TESTING + METALLOGRAPHY OF STEELS.	
16	TMP	DISCUSSIONS REG. NON DESTRUCTIVE TESTING OF MATERIALS + CORROSION CONT.	
17		DISCUSSIONS WITH DESIGNS + CIVIL ENGG. DEPTTS. VISIT TO M/S EGB + OSCHNER PUMPS	
18		HOLIDAY	
19	ATH	DISCUSSIONS WITH ENGRS. REGARDING SYN GAS WASTE HEAT BOILER.	
20		HOLIDAY	
21		HOLIDAY.	
22	TME	GENERAL VISIT TO INSTRUMENT DEPTT	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. P. Kumar
Nationality: India

81 Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature CL
ne 23	ATN	DISCUSSION ABOUT PROBLEMS OF CAN AMM SULPHATE, AN + BAC PLANTS	
24	GEN	VISIT TO ACRYLONITRYL PLANT ENNS + BEARING MONFACT STEYR	
25	GENL	COST CONTROL, FINAL MEETING UNIDO, POLLUTION CONTROL	
26	GENL	FINAL DISCUSSIONS · REG. MAINT	
27			

TEILNEHMER am " 4. UNIDO - WORKSHOP ON FERTILIZER PLANT MAINTENANCE " 11.5.1981 - 26.6.1981

Nr.:	Teilnehmer:	Geb.Datum,Geb.Ort:	Anschrift:	Beruf:
1.	Mr. Md. Mansur RAHMAN Bangladesh	13.12.1952 Dacca, Bangladesh	No. F 130, Officers Mess. NGFF Denchergang, Sylhet	Mech.Engin.
2.	Mr. Abul Ula Mohammed ZUBAIR Bangladesh	3. 3.1954 Chittagong,Banglad.	TSP Complex Ltd.,Chittagong	Mech.Engin.
3.	Mr. Zhichao YANG China	12.1934 Guangdong, China	The Petrochemical Plant Guangzhou	Elec.Engin.
4.	Mr. Dessoki Ramadan RAMADAN Egypt	10.12.1946 Kaluob, Egypt	Semadco, Talkha	Mech.Engin.
5.	Mr. Prem KUMAR India	4. 2.1936	National Fertilizers Ltd. Nangal Unit, Naya Nangal 140126 District Roopnagar (Punjab)	Mech.Engin.
6.	Mr. Mursidi KASDIOPRANOTO Indonesia	30. 8.1939 Sala, Indoresia	P.T. Petrokimia Gresik Jl. A. Yani, Gresik	Mech.Engin.
7.	Mr. Johannes PUDJIHARTO Indonesia	7.10.1938 Prembun, Indonesia	(same as above)	Mech.Engin.
8.	Mr.José António Matos SILVA COSTA Portugal	19. 2.1950 Aveiro, Portugal	S. Sebastio, 3860 Avanca	Mech.Engin.
9.	Mr. Antonio Mario FERREIRA Portugal	19. 5.1941 Figueira Da Foz, Portugal	Direccao de Manutencao Quimigal, 2830 Barreiro	Mech.Engin.
0.	Mr. Abdul Hassib EL-ASMAR Syria	15. 3.1951 Homs, Syria	Homs, Syria P.O. Box 280	Mech.Engin.
1.	Mr. Murat ERCAN Turkey	8. 6.1954 Istanbul, Turkey	Azot Sanayii TAS Gemlik Tesisleri, Gemlik/Bursa	Mech.Engin.
2.	Mr. Rifat GÜNEBAKAN Turkey	21. 5.1940 Gaziantep, Turkey	Azot Sanayii Tas, Isl. Kontrol, Sef Müh., Gemlik	Instr.Engin.

UNIDO - WORKSHOP 1981 - PROGRAMME

WEEK		ATH	ATG	ATN	ATP	PTH	THW	TEL	TME	TMP
		AMMONIA	WATER SUPPLY GAS-REFORMING, OXYGEN	CAN, AN, AS NITRIC ACID, BAG PROD.	H_2SO_4, NPK, CEMENT, H_3PO_4, SSP	UREA MELAMIN	CENTRAL WORK-SHOP	ELECTRICAL DEPT.	INSTRUMENT DEPT.	MATERIAL TESTING
1. 20	11.5. - 15.5.	GENERAL INFORMATIONS								
2. 21	18.5. - 22.5	1,5,6,7					2,9,10,12	3,4, 8,11	3,11, 6,11	
3. 22	25.5. - 29.5 285. FREE		2,10			4,5 / 2,10	1,3,8,11			5 / 6,7,9,12
4. 23	1.6. - 6.6.		4,5, 6,7	2,9,10,12	1,5, 6,7		3,8,11 / 1 4			
5. 24	9.6. - 12.6. 8.6. FREE			1,3,11 / 5	2,4,8,9,10		6,7 / 5		12	
6. 25	15.6. - 19.6. 18.6. FREE	5, 3 / 4,10 | 5		4,8	2,9 / 8 | 10			5,7	6,12 / 5,7	5 / 1,11
7. 26	22.6. - 26.6.		1,11 (7)					6, 12 (7) / 9,10 | 5	5 | 9,10	2,3,4,5, 8(7)

PARTICIPANTS:

1	MR. RAHMAN	BANGLADESH	M
2	MR. ZUBAIR	— " —	M
3	MR. YANG	CHINA	M
4	MR. RAMADAN	EGYPT	M
5	MR. KUMAR	INDIA	M
6	MR. MURSIDI	INDONESIA	M
7	MR. TUDJIHARTO	— " —	M
8	MR. SILVA-COSTA	PORTUGAL	M
9	MR. FERREIRA	— " —	M
10	MR. EL-ASHAR	SYRIA	M
11	MR. ERCAN	TURKEY	M
12	MR. GÜNEBAKAN	— " —	I

GENERAL MEETINGS:

13.5.	8.45 - 12.00	US	SAFETY
	13.30 - 16.30	TBW	CIVIL DEPT.
20.5.	8.45 - 12.00	TME	INSTRUMENT DEPT.
	13.30 - 16.30	THW	CENTRAL WORKSHOP
27.5.	8.45 - 12.00	TEL	ELECTRICAL DEPT.
	13.30 - 16.30	TMP	MATERIAL TESTING
4.6.	8.45 - 11.15	TKB	DESIGN
	11.30 - 12.30	UNIDO	SERVICE
	14.00 - 15.00	UNIDO	INVESTMENT PROMOTION
	15.00 - 16.30	GBR	WORKS COUNCIL
25.6.	11.30 - 12.30	UNIDO - FINAL MEETING	

VISITS TO OTHER COMPANIES:

25/6 9 - 11.00 Cost control
11-15/6 12-13 UNIDO FINAL
14-16 Pollution control, Heating

Visits by other Co.

12-6 — Voest Alpine
Pcs — Schwechat
13-6 —
17-6 — EBG — Linz
Oesterr. + Linz
24-6 ENNS
+ TEYR

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: MURSIDI M.
Nationality: INDONESIA

Project: UNIDO-Workshop

Day Date	Dept.	Aktivities	Signature CL
10.		ARRIVAL IN VIETNAM, ATTENDED BY CL	
11.		OPENING OF THE 4th WORKSHOP, INTRODUCTION TO CL MANAGER	
12.		WORKSHOP PROGRAMME, ORGANISATION OF CL	
13.		INSTRUCTIONS ON SAFETY MEASURES, DISCUSSION W. CIVIL DEPARTMENT	
14.		FUNDAMENTALS OF MAINTENANCE START UNITS SYSTEM OF CL	
15.		REPAIR ORGANISATION OF CL, VISIT TO MAINTENANCE & MAINTENANCE ATH	
16.		HOLIDAY	
17.		HOLIDAY	
18.	ATH	DISCUSSION ABOUT SOME COMPRESSOR (RECIPROCATING & CENTRIFUGAL AND SOME PROBLEMS / PLANT VISIT TO COMPR. HOUSE	
19.	ATH	DISCUSSION ABOUT MAINTENANCE ORGANISATION SOME PROBLEMS AND AUTOMATIC SHUTDOWN / PLANT VISIT TO [illegible] PLANT	
20.	THE/TMP	THE ORGANISATION SHIFT AND STANDBY / TMP SCOPE OF WORK SERVICE, GENERAL SCOPE OF WORK	
21.	ATH	DISCUSSION ABOUT AIR COMPRESSOR SOLUTION PUMP / PLANT VISIT TO SINGLE WITH N2 INJECTION AND SOME CLOSURE TRAIN UNIT	
22.	ATH	DISCUSSION ABOUT NON TECHNIC : PERSONAL, BUDGET ETC	
23.		EXCURSION TO HEAT PLANT OF CL NEAR SALZ BURG	
24.		HOLIDAY	
25.	TMP	DISCUSSION ABOUT SCOPE OF WORK AND / TO STUDY LEARNING TEST POINT OF SOME PROBLEM AND EVALUATION / PVC LINER & CERAMIC LINER	
26.	TMP	RADIOISOTOP, X-RAY, TENSILE STRENGTH MEASUREMENT, HARDNESS MEASUREMENT, METALLOGRAPHY AND PRESSURE TEST	
27.	TEL/THW	TEL ORGANISATION, TENDER SUPPLY, BALANCING MACHINE / ORGANISATION & SCOPE OF WORK.	
28.	~~Palace~~	HOLIDAY	
29.	TMP.	IMPACT STRENGTH, HARDNESS, CHEMICAL LABORATORY.	
30.		HOLIDAY	
31.		HOLIDAY	

CHEMIE LINZ AG

IVL

RECORD OF WORKING TIME

Month: June 1981

Name: Mr M. Kasdiopranoto

Nationality: Indonesia

Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature CL
ıe 1	ATG	DISCUSSION ABOUT ATG ORGANISATION, [illegible]	
2	ATG	DISCUSSION ABOUT MAINTENANCE AND MATERIAL AND/VISIT [illegible]	
3	ATP	DISCUSSION ABOUT ATP ORGANISATION, [illegible]	
4	MEETING	TKB DIVEN / UNIDO / CBR WORKS COUNCIL	
5	ATP	DISCUSSION ABOUT SOME PROBLEM IN ASSY & ATP PLANT TO VISIT SEC PLANT & [illegible]	
6		EXCURSION TO HYDRO POWER STATION UNZ.	
7		HOLIDAY	
8		HOLIDAY	
9	TMW	DISCUSSION ABOUT TMW ORGANISATION, [illegible]	
10	TMW	DISCUSSION ABOUT REPAIR & ASSEMBLE [illegible]	
11	MEETING/TMW	SYMPOSIUM REINZ GASKET WEST GERMANY / TO VISIT PLASTIC, TMW WORKSHOP	
12		EXCURSION TO VOEST ALPINE.	
13		EXCURSION TO PETROCHEMICAL PLANT VIENNA & VIENNA CITY.	
14		HOLIDAY.	
15	TRV/TME	SAFETY VALVE REPAIR / VISIT TO CENTRAL VALVE REPAIR WORKSHOP / FIELD WORK SITE WORKING WITH STAFF	
16	TME	WORKSHOP: MECHANIC WS FOR REDUCTION, NEEDLE VALVE; INT MECHANIC; METAL SHEET; PNEUMATIC; CONTROL MECHANIC; ALLOY PANEL; WELDER PANEL	
17		MEETING WITH DESIGN DEPT; CIVIL DEPT / VISIT TO E.B.G.	
3 ~~18~~	TRAINING DEPT/TME	TRAINING CENTER / INSTRUMENT DEPT.	
9 ~~19~~		HOLIDAY (THURSDAY)	
20		HOLIDAY (SATURDAY)	
21		HOLIDAY (SUNDAY)	
22	TEL.	ELECTRICAL WORKSHOP, [illegible]	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr.M. Kasdiopranoto
Nationality: Indonesia

81 Project: UNIDO-Workshop

te	Dept.	Aktivities	Signature Cl.
ne 23	TEZ	[illegible]	
24		TO VISIT CHEMIE LINZ AG NETHERLANDS & VITA-R-WAZ LACKE COMPANY	
25		MEETING WITH EAST GERMAN / HUNGARIAN / [illegible]	
26	TEZ	[illegible]	
27			

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: MAY 81 (2)
Name: I. PUDJIHARTO
Nationality: INDONESIA

1981 Project: UNIDO-Workshop

Date	Dept.	Aktivities	Signature CL
May 10	GENERAL	ARRIVAL IN VIENA. ATTENDED BY C.L.	
11	"	OPENING OF THE 4TH WORKSHOP, INTRODUCTION TO CL MANAGER	
12	"	WORKSHOP PROGRAMME, ORGANIZATION OF CL	
13	"	INSTRUCTIONS ON SAFETY MEASURES, DISCUSSION W/ CIVIL DEPT.	
14	"	FOUNDAMENTALS OF MAINTENANCE SPARE PARTS SYSTEM OF CL	
15		REPAIR ORGANIZATION OF CL, VISIT TO MAINTENANCE DPT. ATP	
16	-	HOLIDAY	
17	-	HOLIDAY	
18	ATH	MORNING DISCUSSION WITH ATH MGR. AFTERNOON PLANT-TOUR ACCOMPANIED BY CHIEF FOREMAN	
19	ATH	MORNING DISCUSSION CONTINUED. AFTERNOON WITNESS FOR REPAIR WORK While Plant Shut-down	
20	GENERAL	General meeting with TME and TMP.	
21	ATH	MORNING DISCUSSION WITH ATH. MANAGER AFTERNOON PLANT-TOUR	
22	ATH	MORNING DISCUSSION WITH ATH MGR CONTINUED, AFT. WITNESS FOR REPAIR WORK Recipr. compr.	
23	GENERAL	VISITED PEAT PLANT NEAR SALZBURGH	
24	-	HOLIDAY	
25	TMP	MORNING DISCUSSION WITH TMP MGR, AFTERNOON WITNESS ULTRASONIC TEST AT FIELD	
26	"	MORNING DISCUSSION CONTINUED, AFTERNOON WITNESS RESTRUCTURATION AT LAB	
27	GENERAL	GENERAL MEETING, MORNING WITH TEL DEPT, AFT WITH TMP	
28	-	HOLIDAY	
29	TMP	WITNESS FOR DEMONSTRATION IMPACT TEST AT LAB, AND SOME DISCUSSION	
30	-	HOLIDAY	
31	-	HOLIDAY	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. J. Pudjiharto(?
Nationality: Indonesia

Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature CL
ıe 1	ATG	MORNING DISCUSSION WITH ATG MGR AFTERNOON PLANT TOUR	
2	ATG	MORNING DISCUSSION WITH ATG MGR CONT AFTERNOON PLANT TOUR.	
3	ATP	MORNING DISCUSSION WITH ATP Mgr., AFTERNOON PLANT VISIT	
4	GENERAL	MORNING MEETING WITH TMP DEPT & UNIDO AFT MEETING WITH UNIDO & GGR WORK COUNSIL	
5	ATP	MORNING DISCUSSION WITH ATP Mgr., AFTERNOON PLANT VISIT	
6	GENERAL	~~HOLIDAY~~ VISITED POWER STATION, LINZ (ABWINDEN)	
7	-	HOLIDAY	
8	-	HOLIDAY FIRST MONDAY	
9	THW	MORNING DISCUSSION WITH THW Mgr, AFTERNOON WORKSHOP WORK	
10	THW	" WITH CONT. REPAIR WORK OF WELDING SEAMS AFT. AFTERNOON CABLE DYNAMICS	
11	THW	" " PLASTIC WORK & SHEET METAL	
12	GENERAL	VISITED VOEST ALPINE, LINZ	
13	GENERAL	VISITED PETROCHEMICAL PLANT IN SCHWECHAT	
14	-	HOLIDAY	
15	TMP	MORNING DISCUSSION WITH TMP Mgr, AFTER. WORKSHOP, PLANT TOUR	
16	TMP/ATN	MORNING AT TMP DEPT WITH ATN DEPT DISCUSSION WITH THE MGR	
17	GENERAL	GENERAL MEETING. CIVIL DEPT.; DESIGN DEPT; EBG & CONSULTER.	
18	-	HOLIDAY FEAST OF CORPUS CHRIST	
19	GENERAL	~~VISITED EBG & DESIGNER, LINZ~~ CONTINUE AT ATN, PLANT VISIT	
20		HOLIDAY	
21		HOLIDAY	
22	TME	MORNING DISCUSSION WITH Mgr OF TME AFT WORKSHOP VISIT.	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. J. Pudjiharto (7)
Nationality: Indonesia

81 Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature CL
ne 23	TEL.	Many discussions with TEL Mgt. After plant visit	
24	General	Hand over to E/M's and other heavy m/t	
25	"	General meeting with UNIDO, Cost Control & problem Analysis	
26	"	Final discussion regarding Maintenance	
27			

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: JOSÉ S. COSTA
Nationality: PORTUGAL

Project: UNIDO-Workshop

May Date	Dept.	Aktivities	Signature CL
10.	GENERAL	ARRIVAL IN VIENNA, ATTENDED BY C.L	
11.	"	OPENING OF THE 4 WORKSHOP. INTRODUCTION TO CL MANAGER	
12.	"	WORKSHOP PROGAMME, ORGANISATION OF CL	
13.	"	INSTRUCTIONS ON SAFETY MEASURES, DISCUSSION WITH CIVIL DEPARTMENT	
14.	"	FUNDAMENTALS OF MAINTENANCE, SPARE PARTS SYSTEM OF CL	
15.	"	REPAIR ORGANISATION OF CL, VISIT TO MAINTENANCE DEPARTEMENT TP	
16.	—	HOLLIDAY	
17.	—	HOLLIDAY	
18.	TM.E	ORGANISATION of INST. DEP. and visit to INSTRUMENT WORKSHOP	
19.	"	Visit SPAIR STORES of TME AND control rooms of AMONIUM and UREA PLANT	
20.	General	GENERAL MEETING with INSTRUMENT DEPARTMENT. AFTERNOON MEETING with T.M.P	
21.	T.E.L	VISIT to High and Low Tension Stations AND CONTROL ROOMS of UREA AND AMONIUM Plant	
22.	"	visit Electrical workshop and Testing with Balancing Machine	
23.	General	EXCURSION TO PEAT PLANT OF CL NEAR SALZBURG	
24.	—	HOLIDAY	
25.	THW	ORGANISATION of THW AND visit to main WORKSHOP	
26.	THW	Visit to the Platters, Plastic Material workshop and Carpenterie	
27.	General	MEETING with ELECTRICAL DEPARTMENT. IN AFTERNOON MEETING with CENT. WORKSHOP	
28.	—	HOLLIDAY	
29.	THW	Visit to the Field WORKSHOP, ~~number~~ 1 and 3	
30.	—	HOLLIDAY	
31.	—	HOLLIDAY	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name Mr.J.A.M. Silva Cost.
Nationality: Portugal

31 Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature CL
ie 1	THW	Studying at the central Workshop.	
2	THW	Studying at the central Workshop	
3	THW	Studying at the central Workshop.	
4		Meeting with Unido and investment promotion and C.P.R. visit canceled	
5	THW	Studying at the central workshop.	
6	—	Excursion to Hydro-Electrical Powerstation ABWINDEN	
7	—	Holliday	
8	—	Holliday	
9	ATP	Organization of ATP. visit to S.S.P.	
10	ATP	Phosphoric acid Plant and Gypsum Plant.	
11	ATP	N.P.K Plant.	
12		Visit to Voest Alpine / Linz	
13		Visit to Petrochemie / Vienna	
14	—	Holliday	
15	ATP	Monsanto Plant	
16	ATP	Storen Conveyors	
17		Meeting with Design Department and Civil Department. Visits to EBG and GEHSNER	
18		Holliday	
19	ATP	Discussion of some specific problems	
20		Holiday	
21		Holliday	
22	TMP	Studying at the Material Testing Department	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr.J.A.M. Silva Cost
Nationality: Portugal

81 Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature CL
ne 23	ATV	Visit to CAN and Ammonia Sulfate	
24		Visit to a plant of Coking at CAN's after cost visit to Steyr	
25		Cost Control Final meeting UNIDO POLLUTION CONTROL	
26		Final discussions regarding Maintenance	
27			

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: A.H. FERREIRA
Nationality: PORTUGAL

Project: UNIDO-Workshop

May Date	Dept.	Aktivities	Signature CL
10.	GENERAL	ARRIVAL IN VIENNA, ATTENTED BY C.L.	
11.	"	OPENING OF THE 4 WORKSHOP, INTRODUCTION TO CL MANAGER	
12.	"	WORKSHOP PROGRAMME, ORGANISATION OF CL	
13.	"	INSTRUCTIONS ON SAFETY MEASURES, DISCUSSION WITH CIVIL DEP.	
14.		FUNDAMENTALS OF MAINTENANCE, SPARE PARTS SYSTEM OF CL	
15.	"	REPAIR ORGANIZATION OF CL, VISIT TO MAINTENANCE DEP. ATP	
16.		HOLIDAY	
17.		HOLIDAY	
18.	THW	ORGANIZATION AND FUNCTIONING OF THE CENTRAL WORKSHOP, VISIT TO MACHINE SHOP	
19.	THW	VISIT TO THE CENTRAL WORKSHOP OBSERVED SOME WELDING AND CUTTING PROC.	
20.	THE/THP	ORGANIZATION AND DUTIES OF THE INSTRUMENTATION AND MATERIAL TESTING DEP.	
21.	THW	OBSERVED SOME PUMPS REPAIRS, HANDLING OF HEAT EXCHANGERS AND VISIT TO THE CW STORES	
22.	THW	OBSERVED MANUFACTURING OF HEAT EXCHANGER, VISIT TO POLYPROPYLENE SHOP AND TURNING DEP.	
23.	GENERAL	EXCURSION TO HEAT PLANT OF C.L. NEAR SALZBURG	
24.		HOLIDAY	
25.	THP	ORGANIZATION AND DUTIES OF THP, OBSERVATION OF THE CONTROL OF ENCAPSULATED VESSEL	
26.	THP	OBSERVATION OF SOME NON DESTRUCTIVE TESTS: X-RAY; GAMA-RAY; ULTRA-SONIC DEFECTOR; METALLOGRAPHIC STUDY	
27.	GENERAL	MEETING WITH ELECT DEP. AND WITH ORGANIZATION OF TEL AND BALANCING OF PUMPS	
28.		HOLIDAY	
29.	THP	MECHANICAL METALLURGICAL AND CORROSION TESTS	
30.		HOLIDAY	
31.		HOLIDAY	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: Mr. A.M. Ferreira
Nationality: Portugal

981 Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature CL
ay 10		(INTRODUCTION TO CHEMIE LINZ PT) ARRIVAL AT VIENNA	
11		INTRODUCTION TO CHEMIE LINZ. START AT WORKSHOP	
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CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. A.M. Ferreira
Nationality: Portugal

31 Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature CL
ne 1	ATN	ORGANIZATION OF ATN VISIT TO NITRIC ACID PLANT AND [illegible]	
2	ATN	REPORT ABOUT A COMPRESSOR FAILURE AND THE RESULTING VISIT TO THE PLASTIC BAG PLANT	
3	ATN	VISIT TO SHIP LOADING DEVICE CBC PLANT SOME RUBBER WORKS	
4	GENERAL	MEETING WITH T.K.B. ORGANIZATION AND DUTIES OF ENG DEP. MEETING WITH UNIDO [illegible]	
5	ATP	Visit to CAN Plant. Discussion about the fertilizers cracking problem	
6	GENERAL	EXCURSION TO HYDRO-ELECTRICAL POWERSTATION ABWINDEN	
7	—	Holiday	
8	-	Holiday	
9	ATP	ORGANIZATION OF ATP. VISIT TO S.S.P.	
10	ATP	Visit to Phosphoric Acid Plant and Gypsum Plant	
11	ATP	Simposium about gaskets. Visit to NPK Plant.	
12	General	VISIT TO VOEST ALPINE / LINZ	
13	General	VISIT TO PETROCHEMIE / VIENA	
14	—	Holiday	
15	ATP	Visit to Nitrogen Plant	
16	ATP	Visit to the NPK storages and beginning of tubes. Discussion about Safety Measures in Plant	
17	General	Meeting with Design Dep. and Const Dep. Visits to EBG and OGHSNER	
18	—	Holiday	
19	ATP	Discussion about some specific NPK problems.	
20		Holiday	
21		Holiday	
22	TEL	Visit to the Electrical Workshop and High Tension station.	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. A.M. Ferreira
Nationality: Portugal

981 Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature CL
une 23	TELFINE	Visit to the Control Room of Melamine Plant and CNC Plant. Visit the Instrumentation Workshop	
24	General	Visit to ACN Plant - [illegible] and ~~[illegible]~~ primary ~~Visit~~ Manufacture Stage	
25		Cost Control. Final Meeting Unido Pollution Control	
26		Final Discussions Regarding Maintenance	
27			

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: [illegible]
Nationality: [illegible]

Project: UNIDO-Workshop

May Date	Dept.	Aktivities	Signature CL
10.	general	Arrival in vienna, attended CL	
11.	"	Opening of the w. workshop, introduction to CL manager	
12.	"	Workshop Programme, organisation ~~introduction to CL manager~~ organisation of CL	
13.	"	Instructions on safety measures, discussion with civil department	
14.	"	Fundamentals of maintenance, spare parts system of CL	
15.	"	Repair organisation of CL, visit to maintenance repair unit HTP	
16.	/	Holiday	
17.	/	Holiday	
18.	THW	visit to central workshop THW, maintenance and repair methods in THW	
19.	THW	visit to the workshops in the department	
20.	TME, TAIP	meeting with E TME instrument dept and Testingmaterial dept	
21.	THW	organization about training school in CL; visit to the central work shop	
22.	THW	visit to the training shool, and central work shop	
23.	general	Excursion to Coal Plant of CL near SALZBURG	
24.	—	Holiday	
25.	BTH	visit to BTH dept Storage, bassins, organization, planning of maintenance works, machines.	
26.	BTH, ATG	visit melamine Plant, water treatmeant dept	
27.	GENERAL	Meeting with TEL electrical dpt and central work shop, [illegible]	
28.	/	Holiday	
29.	ATG	visit to water treatment department, steam, work shops, VOEST-ALPINE Plants under ATG.	
30.	/	Holiday	
31.	/	Holiday	

CHEMIE LINZ AG

IVL

RECORD OF WORKING TIME

Month:

Name: El Asmar

Nationali Syria

Project: UNIDO-Workshop

Date	Dept.	Aktivities	Signature CL
1	ATN	visit to Nitric Acid Plant + discussion about the maintenance and treatment in ATN	
2	ATN	Discussion about the trouble and the Repairing in the urea + Prills	
3	ATN	: : reorganization of the new control room in ATN + Urea	
4	general	Meeting with Personnel + Lunch room and meeting with work council	
5	ATN	visit to urea Prill tower + discussion about the technical mechanic system	
6	general	: : Journey to Abwinden ATTN HYDROELECTRIC Plant in Linz	
7	/	Holiday	
8	/	Holiday	
9	ATP	visit to SP Plant + discussion about the materials used in ATP	
10	ATP	: : Gypsum without Acid Plant and Phosphoric Acid Plant	
11	ATP	simposium about gaskets + visit to the Plant	
12	general	visit to VOEST ALPINE/LINZ	
13	general	: : PETROCHEMIE/VIENNA	
14	/	Holiday	
15	ATH	discussion about the maintenance organization and the maintenance of the steam turbine + motor-turbine	
16	ATH + ATP	visit + maintenance Plant + Lagerung + Lubrication and storage of new Equipment	
17	general	meeting with and discussion + design dept + visit in KBG + OSHSNR	
18	/	Holiday	
19	AT	visit to sulphuric Acid Plant + information about the corrosion + Chemicals and possibilities to reduce corrosion Effect	
20	/	Holiday	
21	/	Holiday	
22	TFL	visit to the test workshop there	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. A.H. El-Asmar
Nationality: Syria

981 Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature CL
une 23	[illegible]	visits to the [illegible] departments – visit to the [illegible]	
24	[illegible]	visit to ACRYLONITRYL plant [illegible] STYR	
25	"	[illegible]	
26	"	Final [illegible]	
27			

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: MURAT ERCAN
Nationality: TURKEY

Project: UNIDO-Workshop

May Date	Dept.	Aktivities	Signature CL
10.	General	Arrival in Vienna, attended by CL.	
11.	"	Opening of the 4. workshop, introduction to CL-managers.	
12.	"	Workshop programme, organisation of CL.	
13.	"	Instructions on safety measures, discussion with civil department	
14.	"	Fundamentals of maintenance, spare parts system of CL.	
15.	"	Repair organisation of CL, visit to maintenance department PTP	
16.	—		
17.	—		
18.	TME	Organisation of Inst. Dept, visit to Instr. workshop	
19.	TME	Visit to the spare stores of TME, visit to the control rooms of Ammonia and Urea Plants	
20.	General	General Meetings with the instrument and Material Testing Departments	
21.	TEL	Visit to the high and low tension stations (trafos), visit to the control rooms of Ammonia and Urea Plants	
22.	TEL	Visit to the electrical workshops	
23.	General	Excursion to Power Plant of CL near Salzburg	
24.	—		
25.	THW	Organisation of Central Workshop, visit to the main central workshop.	
26.	THW	Visit to the Carpentary, plastic material and sheet metal workshops	
27.	General	General Meetings with the Electrical and Central Workshop	
28.	—		
29.	THW	Visit to the field workshops number 1 and 3	
30.	—		
31.	—		

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. M. Ercan
Nationality: Turkey

31 **Project: UNIDO-Workshop**

ate	Dept.	Aktivities	Signature CL
ne 1	THW	Repair Works in the old Ammonia Plant and Phosphate Plant	
2	THW	Valve repairing and learning information on welding techniques, lead depositing.	
3	THW	Visit to the training school, mechanical seal repairing, test with the interference equipment	
4	General	Visit to the Eng. Dept.; General Meetings with UNIDO and the Work Council of Chemie Linz.	
5	THW	Heat exchanger tube welding, pump and compressor repairing in the main workshop	
6	General	Excursion to Hydro electric Power Station - Abwinden	
7	—		
8	--		
9	ATN	Organisation of ATN Dept., Visit to the Nitric acid, Ammonium nitrate and bag Manufacturing units.	
10	ATN	Visit to CHN unit and loading facilities	
11	ATN	Seminar on gasket materials, Vulcanization and repairing methods of reactor lids	
12	General	Visit to Voest Alpine / Linz	
13	General	Visit to Petro Chem Plant / Vienna	
14	—		
15	TMP	Discussion on destructive and non destructive testing, destructive testing experiments	
16	TMP	Studied on non destructive testing equipment	
17	General	General meetings with Civil and Design dept's. Visit to ZBB and OCHSNER Plants Dinner with Work Council	
18	—		
19	TMP	Studied on non destructive testing equipment	
20	—		
21	—		
22	ATE	Discussion on the water treatment system of chemie Linz and visit to the water facilities	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. M. Ercan
Nationality: Turkey

81 Project: UNIDO-Workshop

ıte	Dept.	Aktivities	Signature CL
ne 23	ATE	Discussion of the process of steam-naphtha Reforming plant and visit to the plant.	
24	~~ATE~~	Visit to Acrylonitryl Plant in Linz and hearing manufacturer in Steyr.	
25	General	Discussion on cost control and pollution control. Final meeting with UNIDO	
26	~~General~~	Final discussions regarding maintenance	
27			

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: May 1981
Name: Rifat Gunsan
Nationality: T C (Turkey)

Project: UNIDO-Workshop

May Date	Dept.	Aktivities	Signature CL
10.	General	Arrival in Vienna, attended by CL	
11.	"	Opening of the 4 Workshop, introduction to CL Manager	
12.	"	Workshop programme, organisation of CL	
13.	"	Instructions on safety measures, discussion with civil department	
14.	"	Fundamentals of maintenance, spare parts system of CL	
15.	"	Repair organisation of CL, visit to maintenance department MP	
16.		Holiday	
17.		"	
18.	THW	Central Workshop	
19.	"	" "	
20.		Listen instrumentation and Material Testing	
21.	THW	Central Workshop	
22.	"	" "	
23.		~~Holiday~~ Excursion to peat plant of CL near Salzburg	
24.		"	
25.	TMP	Material Testing Department.	
26.	TMP	" " "	
27.		Meeting Central workshop and Electrical Dept.	
28.		Holiday	
29.	TMP	Material Testing Department.	
30.		Holiday	
31.		"	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. R. Günebakan
Nationality: Turkey

Project: UNIDO-Workshop

te	Dept.	Aktivities	Signature CL
e 1	ATN	Nitric Acid CAN, AN, AS and Bag Product	
2	"	" " " " " " "	
3	"	" " " " " " "	
4		planing Dep. General Meeting with Unido and Work Council	
5	ATN	Nitric Acid, CAN, AN, AS and Bag Product.	
6		Visit to Power station (Excursion to Hydro-Elektric power station Abwinden)	
7		Holiday	
8		instrument Department	
9	TME	instrument Department	
10	TME	" "	
11	TME	Morning Seal Gasket sempozium afternoon Instrument Dept.	
12		Visit to Voest Alpine	
13		Visit to Petro Chemie Plant and around Wienna	
14		Holiday	
15	TME	Instrument Dept.	
16	TME	" " aschner	
17		General meeting. E.B.G and visit	
18		Holiday	
19	TME	instrument Dept.	
20		Holiday	
21		"	
22	TEL	I.K. Department	

CHEMIE LINZ AG
IVL

RECORD OF WORKING TIME

Month: June 1981
Name: Mr. R. Günebakan
Nationality: Turkey

981 Project: UNIDO-Workshop

ate	Dept.	Aktivities	Signature CL
ıne 23	T E L	Elk. Department	
24		visit to Acrylonitril plantenns & Bearing manufacture > STEYR.	
25		Cost Control Final meeting UNIDO Pollution control	
26		Final Discussions Regarding Maintennce	
27			

4. UNIDO-Workshop

HISTORICAL EVOLUTION OF CHEMIE LINZ AG

Start of erection in 1940, heaping up the area near the Danube for 2 - 4 meters withgravel from the port.
Question of location: The new plant was situated as a neighbour of VÖEST because there was a surplus of coke oven gas.

The original name of our company was "Österreichische Stickstoffwerke AG" (translated: Austrian Nitrogen Plants Ltd.). Initially only nitrogen fertilizers have been produced. This old name was too complicable and too long for international usage. So we changed it to "CHEMIE LINZ AG" some years ago.

Original layout of our facilities:

1.extension step: 50.000 t N
2.extension step: 100.000 t N
Start of production - Primary N : October 1942
CAN : March 1943

In the year 1944 we had reached a production of 55.000 t primary N.

During the second world war our plant was bombarded by 800 bombs. From May 1945 to July 1946 production partly sood still due to damage and power supply. Until 1948 the former production was reached again. It was boosted strongly in the following years.

	1957	1967	1977
Production of primary N:	164.000 t/a	275.000 t/a	466.000 t/a

The number of different products increased during the same time from 200 to 1300.

The most important results of our chemical - technical investigations you will find in the Know How brochure of our enterprise.

The most significant erections:

1939	Foundation of the enterprise "Österreichische Stickstoffwerke AG" with a layout figure of 50.000 t N.
1943	Start up as an enterprise producing only nitrogenous fertilizers
1944/45	800 bomb-hits, closing of the plant
1945/46	Reconstruction, installation of the departments investigation, development, sale and training.
1948	Foundation of pharmaceutical division and continuous extension of all plants
1953	Foundation of the production line for plant protective agents
1954	Start of the plants "Gypsum Sulphuric Acid" and SSP
1960	Start of organic production facilities (preplastics and plastics)
1975	Erection of the plant at ENNS (acrylonitril)

TABLE OF DEPARTMENTS YOU CAN VISIT DURING THE COURSE

ATH: Division A, technic, high pressure
Single train plant for NH3-production, old ammonia synthesis plant, ammonia storage.

ATG: Division A, technic, gas preparation
Synthesis gas preparation from coke oven gas and natural gas, gas reforming plant, water supply for the whole company, boiler feed water treatment, oxygen plant.

ATN: Division A, technic, nitrogen fertilizers
Nitric acid, CAN, ammonium nitrate, ammonium sulphate, storage, bagging and shipping, plastic bags.

ATP: Division A, technic, phosphate fertilizers
Sulphuric acid and cement from gypsum, sulphur burning plant, single superphosphate, NPK, phosphoric acid, storage for fertilizers and raw materials, bagging and shipping.

BTH: Division B, technic, urea
Urea and melamine plant, storage, bagging

THW: Central technic, main workshop
Manufacture and repair of vessels, heat exchangers, pipes,...
Machining shop, repair of pumps, gears, ...

TEL: Central technic, electrical department
Planning of electrical equipment of new Chemie Linz plants, electrical maintenance, balancing of rotors

TME: Central technic, instrument department
Planning of instrumentation systems, weighing systems, maintenance and repair.

TMP: Central technic, material testing
Recommendation concerning material selection for new and existing plants, check of welding seams, corrosion tests,...

You will have also the opportunity to visit the following departments for a short time:

TBW: Central technic, civil department
Planning of new buildings and maintenance of buildings, streets, rails, sewerage. Insulation and painting group.

US: Safety department
Safety instructions, registration of accidents, fire brigade, safety means (masks, filters, respirators,...)

TKB: Central technic, design
Coordination of all investments (new plants), improvements in existing plants together with production- and maintenance departments, working out of drawings and investment programmes.

IVL: Central planning, licenses
Licenses and Know How from Chemie Linz

GBR: Discussion with members of the works council.

MECHANICAL JOBS FOR OPERATORS

CHEMIE LINZ AG

During start up of a new plant normally we have some maintenance personnel in shift (1 or 2 shift locksmith). If the plant is in continuous operation there is no maintenance personnel in shift. For the complete plant of Chemie Linz only in two departments (ATN and ATP) each one shift locksmith is working. For example the single train ammonia plant, water treatment and also urea plant don't have a shift locksmith. If there is a trouble the operating people (production) can call the stand-by-service (on call service).

For every production department
1 chemical engineer or production foreman -
for every maintenance department
1 mechanical engineer or maintenance foreman and
2 locksmith with good knowledge of the plant are on call for the time of one week after the normal working time and during weekend.

Since some years in Austria the profession "CHEMIEWERKER" (operator for chemical plants) can be learned. After the normal education in school (normal age of the person 15 years) a young person can join e.g. Chemie Linz and can learn for 3 years this profession. During this education in school, workshops and different plants the person becomes familiar with small maintenance jobs. Therefor in Chemie Linz the operators are allowed to fulfill certain maintenance jobs under supervision of the production foreman and in responsibility of the production department.

In the following maintenance jobs allowed for operators are pointed out:

Mechanical jobs allowed for operators in department . . .

After order and instruction by the shift foreman the following jobs are performed by production side after relevant guidance by the maintenance side in the later mentioned units.
Beside the general precautions the following particular safety instructions have to be considered:
Pipes resp. pumps are to depressurize and to drain, hand wheels of valves - if required - are to block, blinds have to be installed, switches for motors are to lock or fuses are to be removed by the electrical department. For jobs with aggressive mediums the common safety means (e.g. goggles, protective suits, rubber boots, gloves etc) have to be used. Flight devices or masks are to keep ready, also water in form of a flexible water tube. In case of escaping NO-, SO2-, CO/CO2- or other dangerous gases the working area has to be left immediately.
In principle all jobs are to be fulfilled in such a way, that neither the worker nor its surrounding will become endangered.

For all jobs up today a work permit was required also in future a work permit is necessary (look to safety instruction no.6 - maintenance jobs in the plant).

General instructions for all jobs

1) Don't use wrench extensions for tightening of screws
2) Tighten nuts on flanges and lids crosswise and uniform
3) Clean sealing surfaces before installation of new gaskets. Treatment of gaskets before use:
   For steam, cold water, hot water, air,
   sulphuric acid, lye — mixture graphite + oil
   Nitric acid, NPK-slurry, ammonia — silicon grease
4) Use only not damaged bolts of sufficient length in the required quality and use not damaged nuts. Grease them before use.
5) In the case of changing armatures pay attention to material pressure range and flow (arrow).
6) The general allowance to fulfill maintenance jobs is limited by nominal pressure 16.
7) Welding jobs are not allowed
8) To erect scaffolds higher than 1,5m is not allowed (call scaffolders).

Gasket material to be used:

Steam, water, condensate, cold gases, compressed air, lyes	Klingerit 400 UNIVERSAL (blue) or Klingerit red
Phosphoric acid	Rubber reinforced by fabric
Nitric acid	Klingerit 400 or Klingerit Acidit
Sulphuric acid 98 %	Klingerit red or Teflon
Sulphuric acid below 76 %, H2SiF6	Klingerit Acidit or Klingerit red
Oils, coating agents	Klingerit oilit or Klingerit red

Beside the already mentioned general jobs for every unit of the department particular jobs are listed up, which are also allowed to be performed by production personnel:
Some examples:

Bagging and shipping (unit 620):

Greasing of vehicles (dumpers, fork lifts, wheel-loaders)	WCWP
Bag welding machines: Turn or change of razor blades	
Clean the filters of the vacuum pump	
Equalize felt-disk	
Clean preheater and pre-pressing device (grease with silicon oil)	WCWP
Replace tubes	
Check and clean cooling water filters	
Adjust ammeter for heater	
Loading of accus	WCWP

Central raw material storage (unit 631):

Change armour plates on conveyor chutes	WWP
Repair small defects on belts	WWP
Change shear-bolts on reclaimers	WCWP
Replace grease nipples and grease tubes	WWP
Clean and oil pneumatic hammers	WCWP
Replace rubber aprons and belt cleaners	WWP

Signed by
Head of production department

Signed by
Head of maintenance department

1960 06 05

Safety instruction 17

MOVABLE ELECTRIC HAND TOOLS AND MOUNTING LAMPS

To fix the required precautions and for the interest of good co-operation with outdoor companies and workers from outdoor companies under observance of ÖVE – instructions E 1 and E 40 the following precautions are ordered:

Movable electric hand tools

1) For jobs in vessels, containers, tubes and similar small equipment of good conductive material and
   for jobs on such equipment with comparable narrow place conditions.
2) Jobs on metallic conductive points such as grids and steel-constructions
3) Jobs on good conductive points (soil, concrete).
4) For jobs on poor conductive points such as workshops with dry and not metallic floors, offices, or tile-floors.

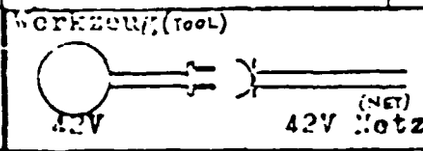
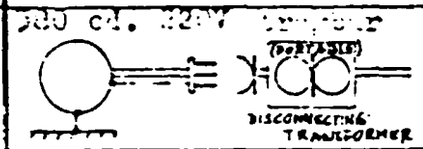
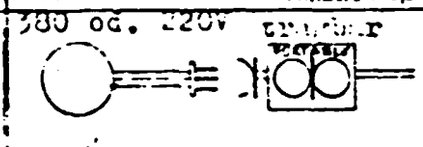
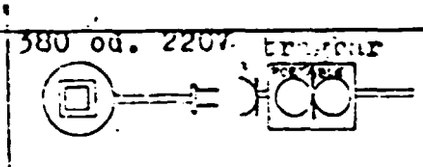
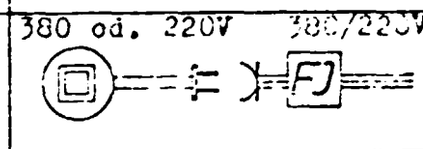
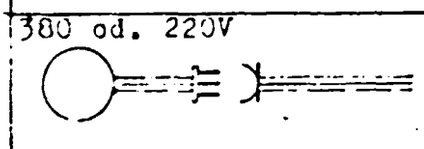
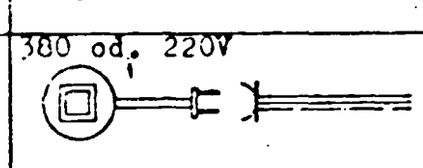
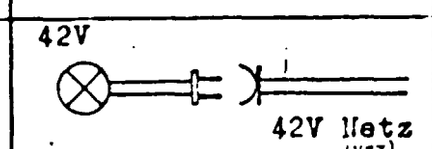
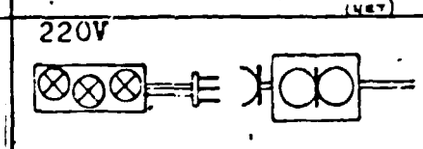
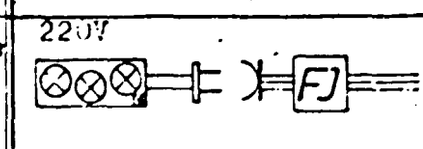
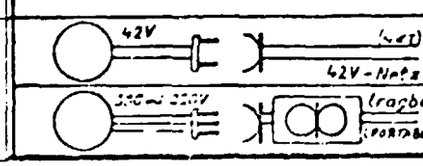
Additional there is mentioned that disconnecting transformers must be located outside of the dangerous rooms and only connection of one electric hand tool is allowed.

On supplement you can see different kinds of electric hand tools and the allowance of use.

● ..... ALLOWED

○ ..... ALSO POSSIBLE

× ..... NOT ALLOWED

TOOL:	WORK:	IN VESSELS AND IN NARROW ROOM CONDITIONS	ON METALLIC CONDUCTIVE POINTS (IRON, STEEL CONSTR.)	ON MOD CONDUCTIVE POINTS (SOIL, CONCRETE)	ON POOR CONDUCTIVE POINTS (WOOD ETC.)
LOW VOLTAGE 42 V		○	○	○	○
ISOLATING TRANSFORMER + ELECTRIC HAND TOOL WITH TERMINAL OF PROTECTING WIRE AND VISIBLE LAYED STANDPOINT-CONNECTION		○	○	○	○
ISOLATING TRANSFORMER + ELECTRIC HAND TOOL WITH PROTECTING WIRE TERMINAL		×	×	○	○
ISOLATING TRANSFORMER + ELECTRIC HAND TOOL WITH PROTECTIVE INSULATION		×	×	○	○
ELECTRIC HAND TOOL WITH PROTECTIVE INSULATION + FAULT CURRENT SWITCH		×	○	○	○
ELECTRIC HAND TOOL WITH PROTECTING WIRE TERMINAL		×	×	×	◐
ELECTRIC HAND TOOL WITH PROTECTIVE INSULATION		×	×	×	◐
HANDLAMPS		◐	○	◐	◐
ISOLATING TRANSFORMER + FIXED MOUNTED MOUNTING LAMPS 220V		◐	○	○	○
FIXED MOUNTED 220V-LAMPS WITH PROTECTIVE INSULATION + FAULT CURRENT SWITCH		×	○	◐	○
LOW VOLTAGE CONCRETE VIBRATORS ISOLATING TRANSF.		×	×	○	◐

Safety instruction 6

MAINTENANCE IN THE PLANT

All jobs in connection with maintenance, erection, servicing, manufacture etc on or for equipments of plants are to be allowed by a person responsible for this plant before start of workmanship. This is done by a written "ALLOWANCE - SHEET" for repair works (see sheet A 79 b), signed by the responsible leader of the certain area or in charge of the leader by a person who is made responsible by the manager of the department.
The allowance sheet is valid only for one certain work.
Due to insignificance or littleness and if there is no risk performance of work is allowed without allowance paper. To fix such a work is the responsibility of ordering- (production foreman) and performing-office (maintenance foreman).
The issuer of the allowance sheet and the performer of the work are responsible for using the preventation-means befor and during the service work.
On principle this allowance sheet shall be for all people concerned with the service job:

1) a memory aid
2) avoiding misunderstanding between ordering and performing side
3) exact determination of precautions
4) clear limited responsibility

The allowance paper has to be signed befor work-performance by the technical st
The original (yellow) of the allowance sheet is kept by the work executing side, the copy (white) remains on the issuer.
If the repair is performed by personell from other workshops (TW, TB,....) the foreman of the other workshop get the allowance paper after instruction from the technical (maintenance) side of the plant and the other workshop confirm agreement to the ordered precautions by signature. Besides this special means of course all the specific instructions for the technical work must be observed. This specific instructions are not written on the allowance sheet.

After finishing the work the responsible person of the executing workshop fills out the tear-off-part of the yellow original sheet with time, date and signature and hand over this part to the issuer. The issuer sticks the tear-off-part to the white copy (specimen) of the allowance sheet.
Because there is a testrun nessersary after finishing the repair, the responsible maintenance man fills out the rubric "SWITCH TO TESTRUN" with time, date and sign it. The foreman of the plant workshop signs also this column and arranges with the production foreman the start of the machine. During testrun the allowance sheet (yellow) is on the production side.
After regular performance of testrun the allowance sheet comes back to the repair-foreman who signs the rubric "WORK FINISHED" and the tear-off-part is handed to the issuer in above described wise.
Can the repair not be finished on the same day one has to ask for extension of allowance. Therefor the issuer has to write a note on the yellow sheet with dublicating to the white copy.
As expedient for making out of allowance sheets and fixing precautions there are provided special supplements in which the danger and the required precaution is mentioned.
Permanent allowance sheets for routine-works can be issued for a limited time of one year after consultation the safety engineer. The issue of required single-allowance sheets befor performance of concerned work is done in own responsibility by the deputies of responsible person (foreman) based on the permanent allowance.
The observance of the ordered safety-instructions by the executing people is controled by the competent supervisor. Allowance sheets for entering of sewages and purification pits must be signed also by the safety department.

Safety instruction 13

SCAFFOLDINGS, LADDERS

For erection of scaffoldings during execution of civil-works the § 1; - 33 of the order about "prevention of workers and employees" is valid, further the standard "ÖNORM B 4007 - scaffoldings." § 35 - 37 and ÖNORM F 5120 concern ladders. Revision of ladders according safety instruction 20.

During erection and working of scaffoldings the following procedure is obligatory: Erection of various scaffold is performed by civil department due to order-sheets (form A 99). The original of this sheet is sent to the civil dept. from the orderer, one copy together with the order for dismantling of the scaffold remain by the orderer and one copy goes to the safety engineer. The safety engineer has the possibility to preceive safety interests on time.

In all the cases that civil dept. has a permanent work order for building of scaffolds, the number of the permanent work order must be written on the order for building a scaffold. Therfore no separate work order is required. Is there no permanent work order by civil dept. beside the order for building a scaffold also a work order is required for accounting the workmanship. The sheets are so arranged that both parts can be written as copies. work order and scaffold order must be handed over to civil dept.
The determination of workmanship in each case is to divide in: Exact place, kind of the scaffold and required load capacity in kg.

The orderer take over the scaffold by signature on the concerning scaffold order (scaffold taken over). Care for the scaffold and to maintain it in a regular state till now is the duty of the orderer. He has to check continuously. He is not responsible for the faultless and regular erection which is the exclusive duty of the scaffolders. But taking over dept. is responsible for the faultless state of the scaffoldings.

To avoid the improper use of not ready scaffolds or sech scaffolds not taken over, the civil dept. has to mark it by a plate "Don't step to scaffold". If the scaffolds are taken over these plates are removed.

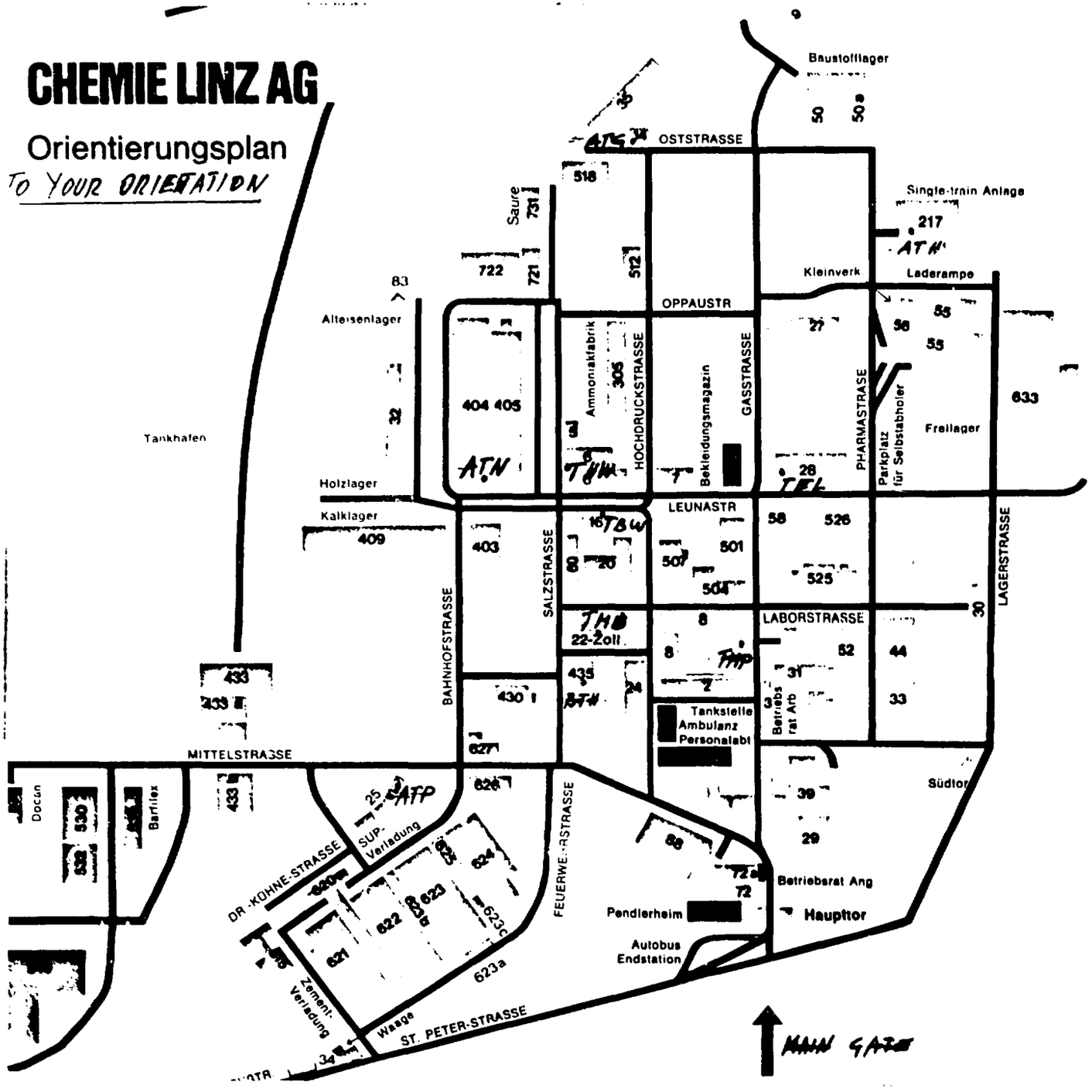
For the case that a scaffold is not used longer, disassembling of the scaffold must be ordered with the sheets 3 - 5 of form A 99. Immediately after beginning disassembly the civil dept. fix the plate "Don't step to scaffold" on the scaffold. Than the scaffold must be removed promptly.

Concerning wooden double-ladders according ÖNORM F 5120 instead of chains there must be used steel-ropes with 4 mm diameter to avoid moving of the two beams (look to safety instruction 20).

CHEMIE LINZ AG

Orientierungsplan

TO YOUR ORIENTATION



Zur Beachtung!

ATTENTION PLEASE!

Ein- und Ausfahrt an den Werkstoren nur nach Einweisung

PASS THE GATE ONLY AFTER INSTRUCTION

Die zulässige Höchstgeschwindigkeit beträgt 15 km/h.

THE MAX. SPEED IS 15 km/h

Rauchen ist im gesamten Werksgelände, mit Ausnahme besonders bezeichneter Bereiche verboten.

DON'T SMOKE IN THE AREA OF CL, EXCEPT IN THE SPECIAL MARKED ROOMS

Das Hantieren mit offenem Feuer ist verboten (Explosionsgefahr!)

DON'T HANDLE WITH FIRE (EXPLOSIONS)

DON'T TAKE PICTURES IN THE PLANT

Fotografieren im Werk ist verboten.

E 100 2 c

WORKING TIME:

In Austria the general working time is 40 hours per week.

General shift:

Flexible working time: Start at morning 6.30 till 8.15 h
3/4 hour interrution for lunch
Close at afternoon, Mo – Thursd. 15.30 till 17.30 h
Friday 12.30 till 14.00 h

Recording of actual working time on "time registration cards".

Zeiterfassungskarte **CHEMIE LINZ AG**

Zeitraum:

Name: _____ v. _____

Kurzzeichen: _____ b. _____

Personalnummer: ± Saldo 1:

Summen der plus- bzw. minus-Abweichungen:

		kommt	Fixzeit	geht	WZ/BZ +	+	–
Mo							
Di							
Mi							
Do							
Fr							

A 41 b

WZ... WASHING TIME
BZ... BATHING TIME

± TOTAL BALANCE
+ Gesamt-
– Saldo:

± BALANCE OF
+ Saldo- FORMER
– Vortrag: CARD

± BALANCE SIDE 1
+ Saldo 1:

SIGNATURE
Unterschrift

± BALANCE SIDE 2
+ Saldo 2:

Summen der plus- bzw. minus-Abweichungen:

	kommt	Fixzeit	geht	WZ/BZ +	+	–
Mo						
Di						
Mi						
Do						
Fr						

The maximum plus- or minus-balance of one complete registration card is allowed with 10 hours. The employees of Chemie Linz can take two free noons or afternoons or one free day per month if they do not go across the 10 hours limit and if the superior give his consent.

Shift systems:

Most of our plants are on stream 24 hours per day. For this production lines in the different departments there are 4 shift groups working 8 hours per day according to a shift table. These groups meet also the 40-hours-week with temporally fixed free-shifts.

Examples for different shift systems:

		A	B	C	D	
2 shift groups A,B	Monday till Friday	6-14	14-22			bagging, loading
3 shift groups A,B,C	Monday till Friday	6-14	14-22	22-6		superphosphate
4 shift groups A,B,C,D	the whole week	6-14	14-22	22-6	FREE	most productions

SUGGESTION SYSTEM

Be clever,
make suggestions !

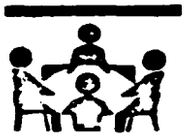
In 1953 Chemie Linz AG has introduced a suggestion system.

How to make a suggestion:

1) The idea:
Everybody can suggest. The office "Suggestion System" and the members of the works council will help composing a suggestion.

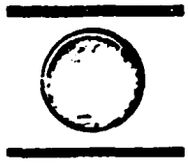
2) Presentation:
Possible over the superior, the office of suggestion system or the works council. One can also put the proposal into the "suggestion-letter-box".

3) Registration and examination:
The office check the suggestion formally and ask for the opinion of one or more experts.



4) The decision:
Acceptance or rejection of suggestions is the duty of a "suggestion-commission".

5) Reward:
The experts calculate the annual savings and the suggestion-commission has to fix the reward.



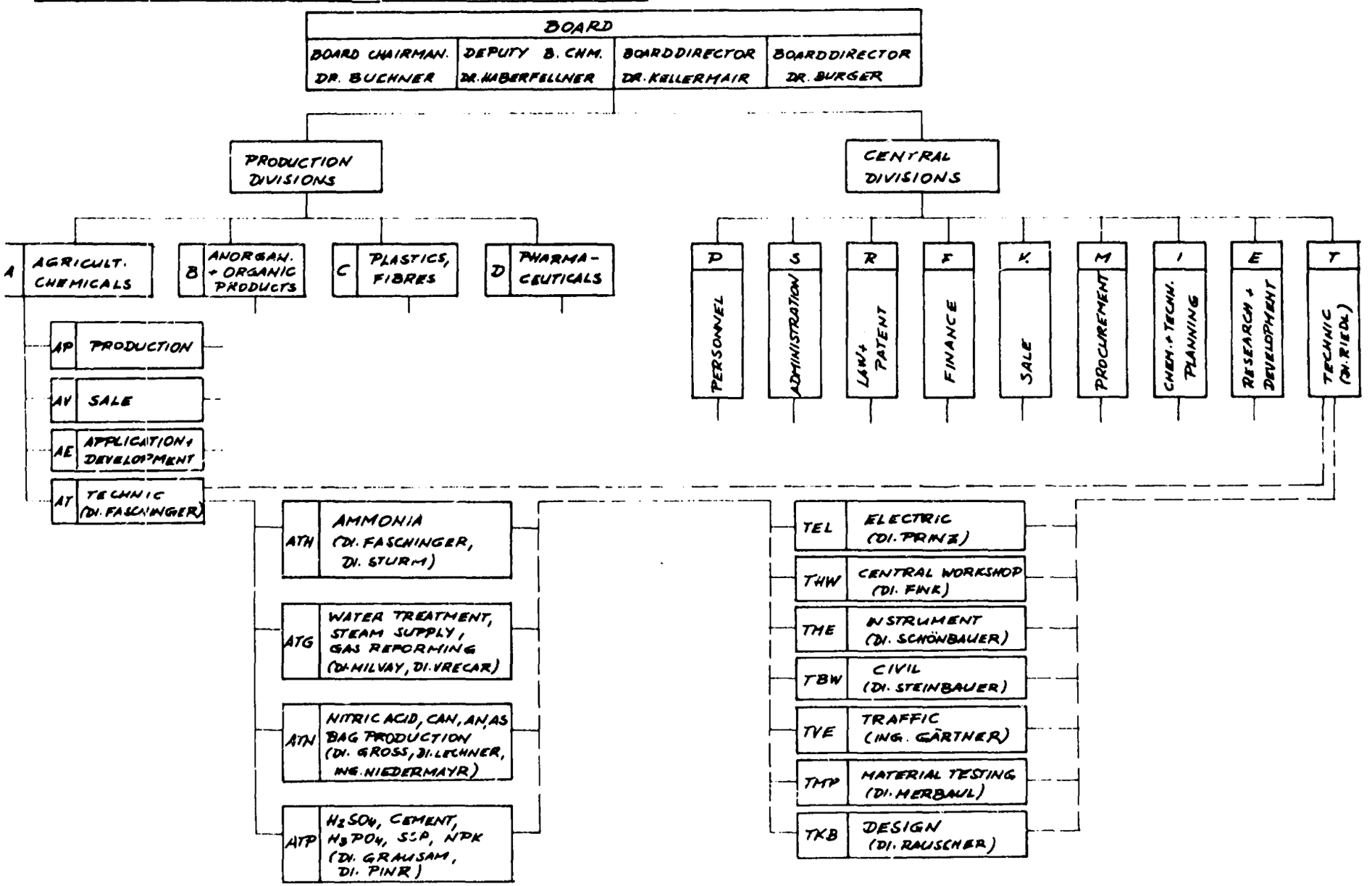
6) Payment:
If the suggestion is positive the employee will get the reward together with the monthly salary.

We distinguish estimable and computable suggestions.
Concerning an estimable proposal one can reward the suggestion with 200,- up to 3000,- shillings, dependent on the result of the valuation system.

Criterions in the valuation system:

Importance	important . . . . . .negligible
Kind of solution	original . . . . . .already used
Effect of the proposal	complete change . . . .insignificant change
Frequency of application	often . . . . . .single
Site of suggestion	own business . . . . .foreign business
Elaboration	practically tested . .not tested
Realization costs	up to S 3000,- . . . . more than S 5000,-

ORGANISATION OF CHEMIE LINZ AG.



SALARY SYSTEM - LEAVE

In Austria there is a collective agreement between the Federation of Trade Unions (labor unions) and the industry. In a distance of 1 to 2 years the two parties fix the wage increase for a certain period.

In Chemie Linz AG there is a special system called "Salary regulation". Our salary is calculated as a sum of four groups:

1) Basic salary (BS)
   It depends on the position of the employee.
   The scale of basic salary is divided into 23 steps.

2) Seniority-value in percent of the basic salary (SV)

$$SV = \frac{67 \text{ . years of service in Chemie Linz}}{90 - \text{entry years (age)}}$$

3) Experience value (EV) in percent of the basic salary.
   This value is 1 % per CL-service-year up to a maximum of 18 %.

4) Personality-value (PV)
   It depends on the opinion of the superior and increases from 0 to 22.6 %.

Monthly salary: BS + SV + EV + PV

Holiday (leave credit)

Up to 20 service years : 24 week-days (4 weeks) Mo - Sa

More than 20 service years: 30 week-days (5 weeks) Mo - Sa

The study-years are accounted in the service-years in the following amount:
Charge for Technical High School : 3 years (duration of school 5 years)
Charge for Technical University : 5 years (duration 5 - 8 years)

More than 25 CL-service years: 30 actual working days (6 weeks)

Additional freetime

for marriage, birth of a child, removal, death of relations in the amount of 1 to 3 days.

Recreaction leave in company own hostels

Every 21 months: Production and maintenance personnel in very dusty and durty areas
27 months: Foremen and workers, laboratories
37 months: Employees in production offices
96 months: Employees in administration offices

Beside the legal rules and directions there exist some other SAFETY INSTRUCTIONS in the company of Chemie Linz AG:

1) General instructions: Competence, foundation, smoking prohibition, alcohol prohibition, maximum speed inside the area of CL, first aid performance, safety advise, . . .
2) Information procedure on fire brigade actions and accidents
3) Operation of fire brigade
4) Alarm ways for the fire brigade
5) Safeguard services
6) Maintenance business
7) Local extinguishers
8) Use of protective hoods
9) Entering of vessels
10) Foreign company workers in the plant
11) Protective equipment and protection clothing
12) Safety instruction
13) Scaffoldings, ladders
14) Storage of burnable materials
15) Use of solvents
16) Radiation protection
17) Portable electric hand tools (power tools)
18) Directions and marks for safety work
19) Responsibility for repairs on pipeline-bridges
20) Bolt shooting devices
21) Directions for chemical labs
22) Apparatus , devices and equipments obligatory to revision
23) Loading works on waggons
24) Transportion tanks
25) Glass carboys (balloons)
26) Steel bottles
27) Pressure vessels
28) Safety in the field of railway
29) Showings round the plant
30) Vehicles without rails (fork lift trucks,..)
31) Alarmplan for special departments
32) Fire protection in glue-plant
33) Report of industrial accidents
34) Transport of prussic acid

Yearly control of all continual conveyors (belt-, chain-conveyors, . .) and notice of the inspection in a check-book.

Yearly earthing control on tanks for burnable materials

Control of the lightning-rods in a distance of 2 years.

The items underlined we will discuss in detail.

UNFALLANZEIGE

ACCIDENT - NOTICE

(Gemäß § 363 des Allgemeinen Sozialversicherungsgesetzes (ASVG), BGBL. Nr. 189/1955.)
Meldepflicht besteht bei Tod oder mehr als drei Tagen Krankenstand. Die Meldefrist beträgt fünf Tage!
Bitte drei Exemplare einsenden! Der weiße Durchschlag ist für Ihre Firma bestimmt.

ALLGEMEINE UNFALLVERSICHERUNGSANSTALT Landesstelle Linz, 4010 Linz, Blumauerplatz 1, Telefon (0 72 22) 54 4 61

GENERAL ACCIDENT INSURANCE COMPANY

1. Firma, Anschrift (Betriebsort), Postleitzahl, Art des Betriebes
COMPANY ADDRESS

2. Zahl der im Betrieb beschäftigt. Personen
NUMBER OF EMPLOYEES

3. Familien- und Vorname des Verletzten (in Blockschrift)
COMPLETE NAME OF THE DISABLED PERSON

4. Versicherungsnummer
INSURANCY - NUMBER

5. geboren am
BIRTH
FOREIGN WORKER

6. Anschrift
ADDRESS

7. Staatsangehörigkeit
NATIONALITY

8. Gastarbeiter
YES ja ☐ NO nein ☐

9. beschäftigt als / im Betrieb seit / Abteilung
WORKING AS

10. Fam. Stand
FAMILY STATUS
FOR SWISS

11. Anz. d. Kinder unter 18 Jahre
NUMBER OF CHILDREN'S UNDER 18 YEARS

12. Lehrling ☐ APPRENTICE | ausgelernt ☐ SKILLED | angelernt ☐ TRAINED | Hilfsarbeiter ☐ UNSKILLED

13. Name und Dienststellung des zustandigen Vorgesetzten
NAME AND POSITION OF COMPETENT SUPERIOR (SUPERVISOR)

14. Vorgesehener(s) Arbeits– Beginn START OF WORK Ende END OF WORK

15. Zuständige Krankenkasse / Kontonummer
COMPETENT SICK-FUND

WORKER Arb. ☐ Ang. EMPLOYEE

16. Vorbeschadigung (Arbeitsunfall, Berufskrankheit, Wehrdienstbeschadigung, Invaliditat, Opferfursorge) mit Rentenbezug von
PREVIOUS INJURIES

17. Unfallstelle im Betrieb (z.B. Standerbohrmaschine, Kran; Aufstellungsort und Fabrikationsnr.)
PLACE OF ACCIDENT IN THE PLANT

18. Wochentag / Datum / Uhrzeit des Unfalles
WEEK-DAY / DATE / TIME OF ACCIDENT

19. Wenn nicht ident mit Betriebsanschrift: Genaue Anschrift der Unfallstelle (Ort, Straße, Hausnr., Bundesland)
IF NOT IDENTICAL WITH COMPANY ADDRESS - EXACT ADDRESS OF ACCIDENT-PLACE

20. Arbeit eingestellt am / Uhrzeit
WORK FINISHED
DATE / TIME

21. Verletzter Körperteil und Verletzungsart
INJURED PART OF THE BODY AND TYPE OF INJURY

22. tot DEATH
YES ja ☐ NO nein ☐

23. In welches Krankenhaus eingeliefert? An welchem Tag?
TO WHICH HOSPITAL TAKEN ? WHAT DAY

24. Erste Hilfe im Betrieb?
YES ja ☐ NO nein ☐
FIRST AID IN THE PLANT

25. Erstbehandelnder Arzt / derzeit behandelnder Arzt (Name und Adresse)
FIRST / TODAY MEDICAL TREATING-DOCTOR

26. Schilderung des Unfallherganges, so daß sich jedermann ein klares Bild machen kann. (Arbeitsverrichtung und Unfallursache, eventuell Art der beteiligten Fahrzeuge)
DESCRIPTION OF THE ACCIDENT - IN SIMPLE WORDS UNDERSTANDING FOR EVERYBODY

27. Bei Wegunfällen: Von wo ist der Verletzte weggegangen? Wohin sollte er sich begeben?
ACCIDENTS ON THE WAY: WAY OF THE DISABLED PERSON FROM - TO

28. Unfallzeugen (Name, Anschrift)
WITNESS OF THE ACCIDENT

29. Arbeit wieder aufgenommen am
RESUMPTION OF WORK

30. Erhebung durch Polizei oder Gendarmerie? Dienststelle?
INQUIRY OF POLICE ?

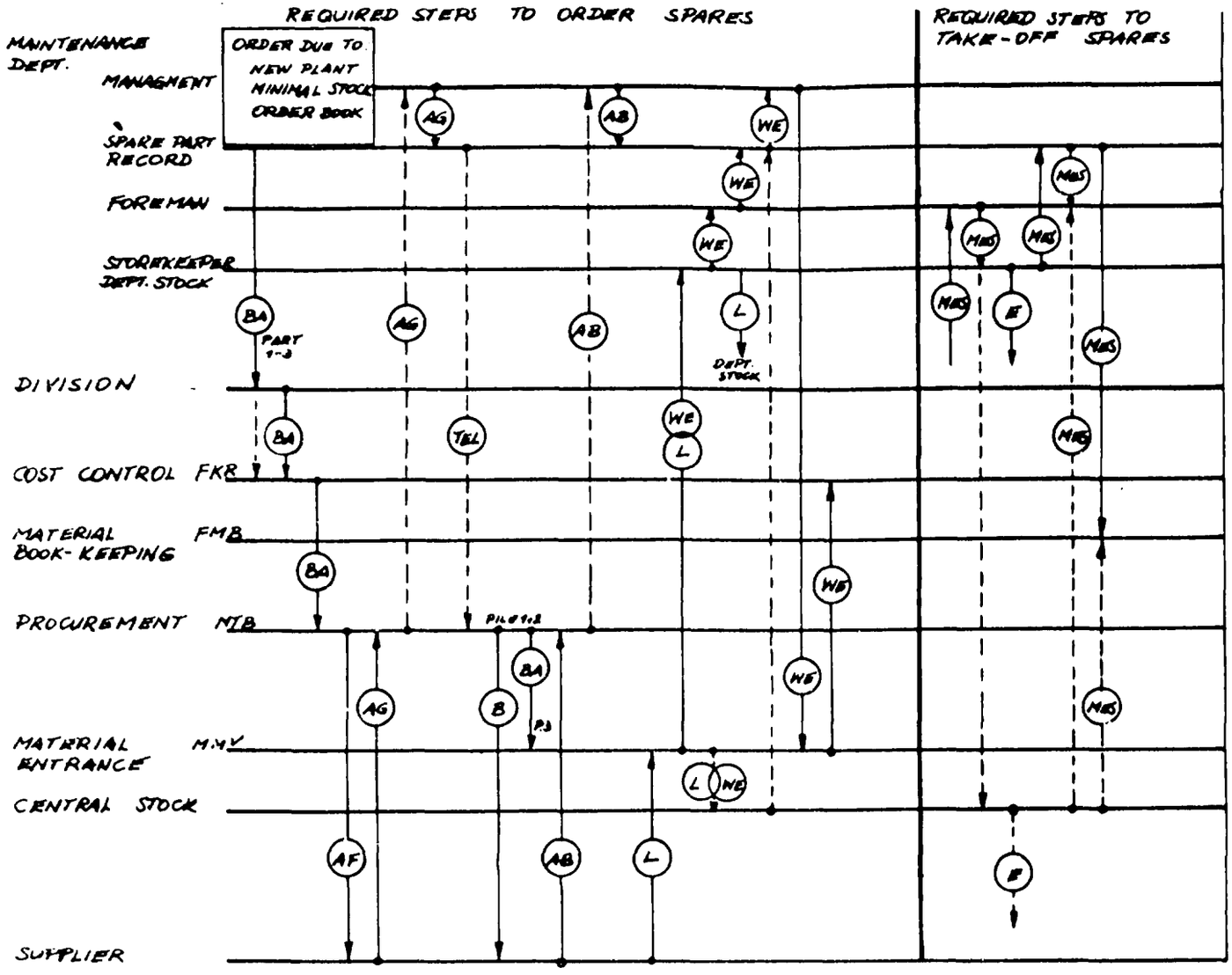
31. Welche Maßnahmen werden getroffen, um kunftig ahnliche Unfalle zu vermeiden?
WHAT MEASURES WILL BE TAKEN, TO PREVENT SUCH ACCIDENTS IN THE FUTURE

32. Ort, Datum
PLACE, DATE
CHEMIE LINZ AG
Firmenstempel, firmenmäßige Zeichnung

LLA - 1 - 0178

U – Nr.

PROCEDURES FOR ORDERING SPARE PARTS IN CHEMIE LINZ AG



ABBREVIATIONS:

BB	BESTELLBUCH ORDER BOOK
ML	MINIMALER LAGERBEST. MINIMAL STOCK
BA	BEDARFSANMELDUNG DEMAND ORDER
AF	ANFRAGE INQUIRY
AG	ANGEBOT OFFER
TEL	TELEFONAT TELEFON-CALL
B	BESTELLUNG ORDER
AB	AUFTRAGSBESTÄTIGG. CONFIRMATION OF ORDER
L	LIEFERUNG DELIVERY
WE	WARENEINGANG MATERIAL ENTRANCE FORM
MES	MATERIALENTNAHMESCH. MATERIAL TAKE OFF FORM
E	ERSATZTEIL SPARE PART
EL	ERSATZTEILLAGER SPARE PART STOCK

ENCLOSURE: AF/BA/WE/MES

ATP/ 1979 09 03 / Lenz

Example for inventory record

610/021 Sulphur melting pit, 21.000 x 4.300 x 1500 mm
with coils and agitator
Three phase current motor, 5.5 kW, 1400 RPM,
gear transmission to 84 RPM, motor-number 693970

610/022 Sulphur pump, vertical type, size 1 1/4,
VSO - 861 - 1/4, temperature of molten sulphur
135 °C Fa. Lewis & Co
TPC-motor, 4,8 kW, 2870 RPM, motor-number 694200

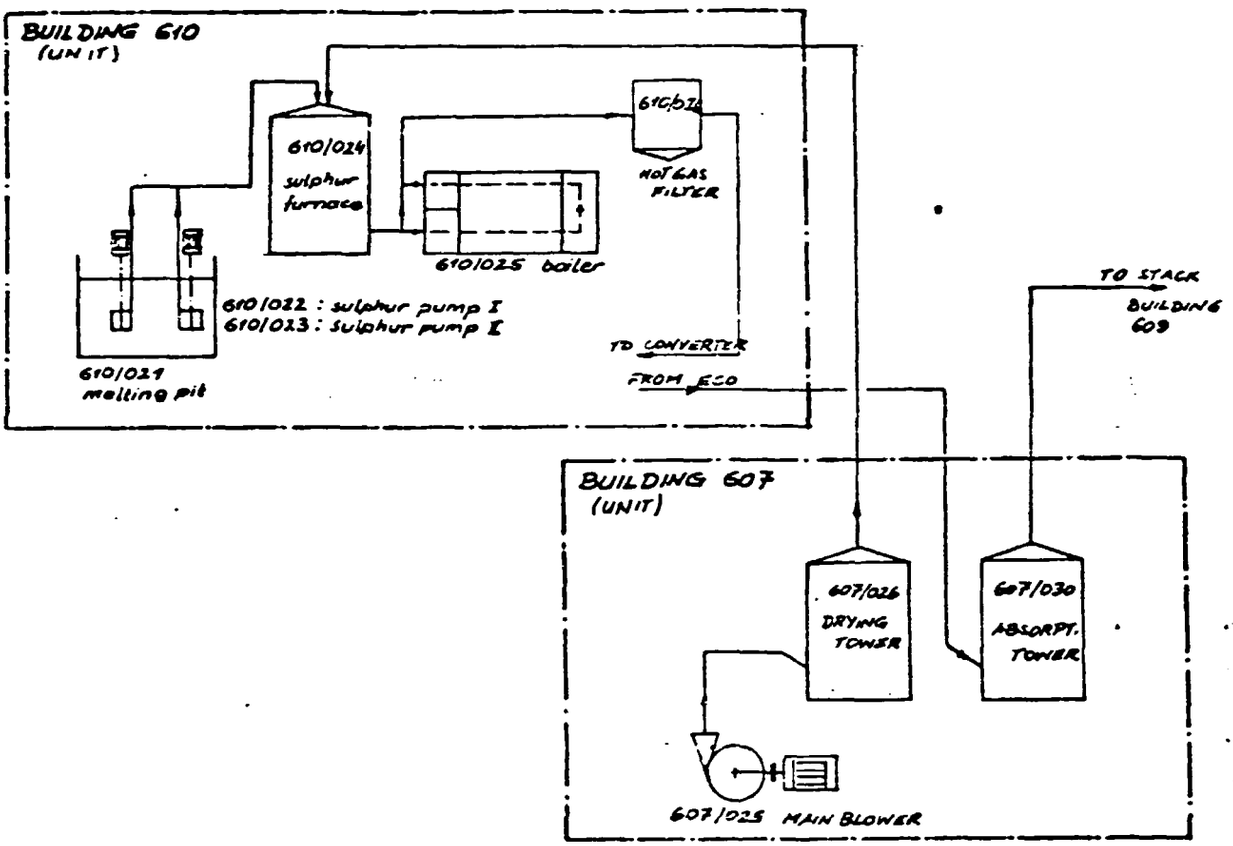
610/023 Sulphur pump, equal with 610/022
TPC-motor 4,8 kW, 2870 RPM, motor-number 694201

610/024 Sulphur furnace, vertical construction,
3130 Ø x 7750 high, steel shell, brick lined
manufacturer Reisner & Wolf

610/025 Waste heat boiler 1800 Ø x 7600 long, 225 m2 surface, 16 kp/cm2 steam pressure, insulated,
registration number 2236,
boilerfeedwater-drum 1500 Ø x 5000 long, 10 m3
volume

610/026 Hot gas filter . . . . . .

INVENTORY SYSTEM



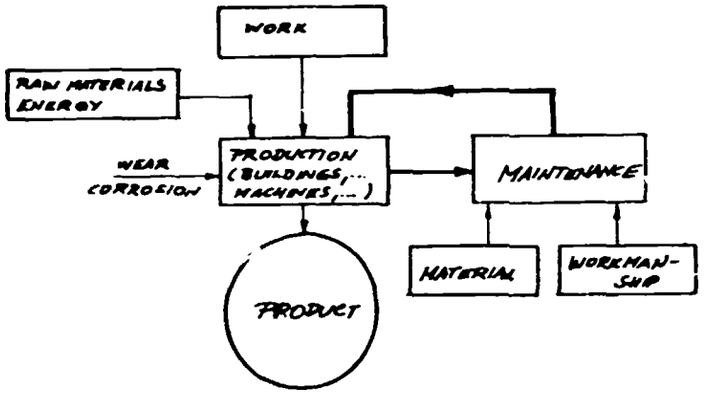
Each building in the company has an own number. For administration buildings the numbers 1 - 99 are reserved. For the different buildings in the plants the numbers 100 - 999 are in use. Each machine and apparatus has an apparatus-number (e.g. 610/024 - sulphur furnace of Monsanto plant). The first three figures mark the building (UNIT) in which the machine is in action. The second three figures determine different machines in a certain building (UNIT). Electrical motors are separately numbered and inventoried by the electrical department. All machines and motors in the field and the replacements in the stock are marked with the apparatus number.

LECTURE

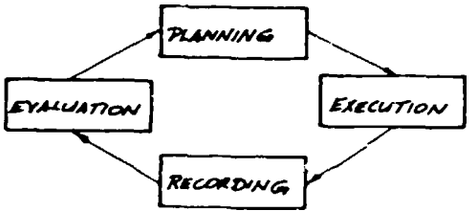
FUNDAMENTALS OF MAINTENANCE

1) Production and maintenance

Position of maintenance in a production process



2) The maintenance cycle



3) Some technical terms

Administration

Precentive maintenance

Corrective maintenance

Modification

Replacement

Direct preventive maintenance

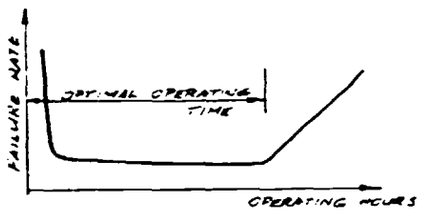
Indirect preventive maintenance

Subjective inspection

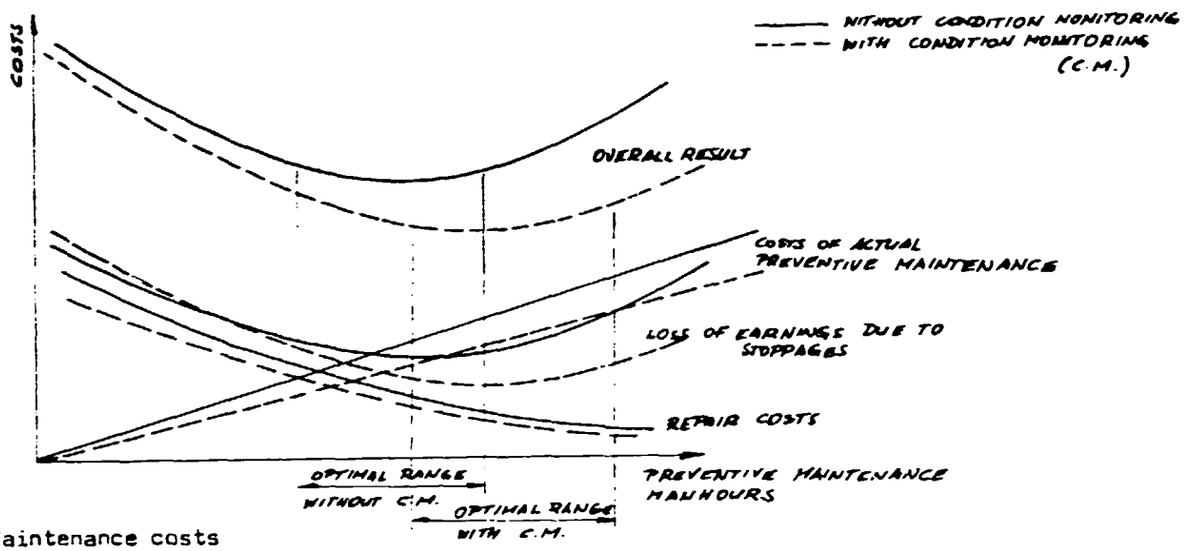
Objective inspection

Surveillance

Bath tub effect



4) The economic effects of preventive maintenance



5) Maintenance costs

Wage costs

Material costs

Administration costs

Purchased services

Conversion costs

Direct maintenance costs

Indirect maintenance costs:

6) Maintenance in a production process

a) Operation
b) Control
c) Care
d) Maintain
e) Check
f) Repair

Duties of production department

Duties of maintenance department

7) Maintenance and company-intern organization

8) The man in the maintenance process

9) Wear - reason for maintenance

Wear

Corrosion

Fatigue

Ageing

Kinds of wear:

10) Wear- and corrosion-phenomenons

a) Even and scarred corrosion

b) Hole corrosion

c) Intercrystalline corrosion

d) Transcrystalline corrosion

e) Layer- corrosion

f) Bacterium corrosion

g) Crevice corrosion

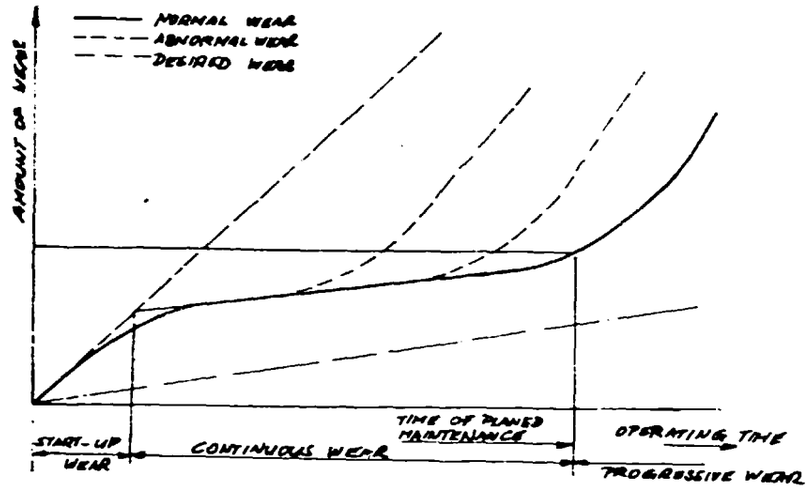
h) Fatigue

i) Ageing

k) Thermal influences

11) Types of faults

12) Registration of wear-processes



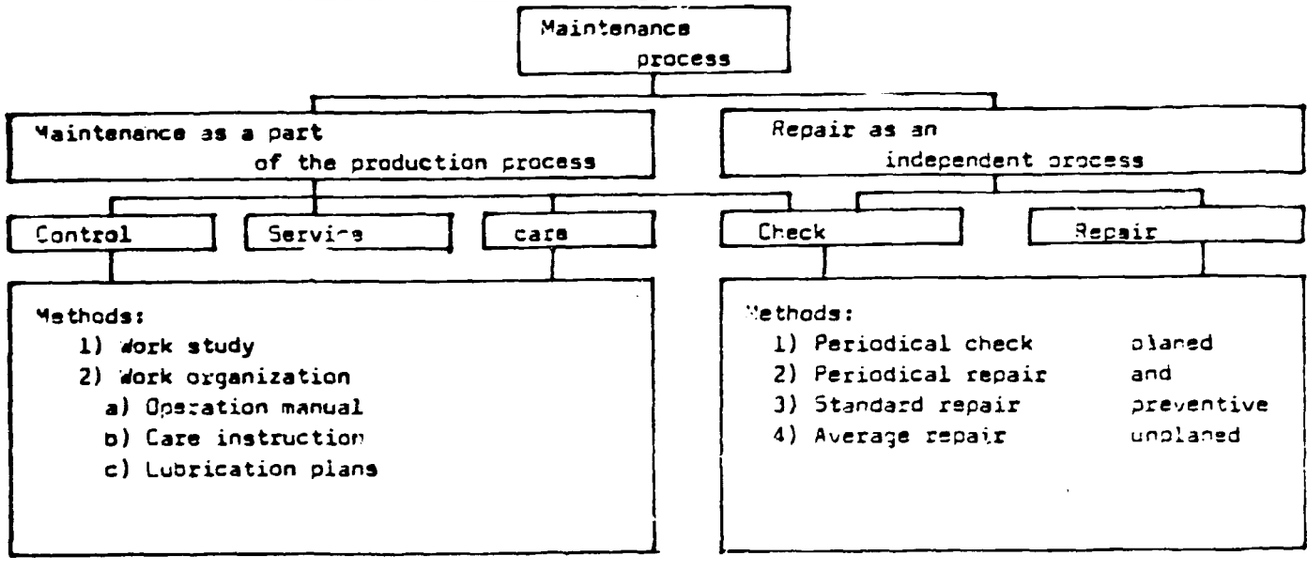
13) Defence of wear

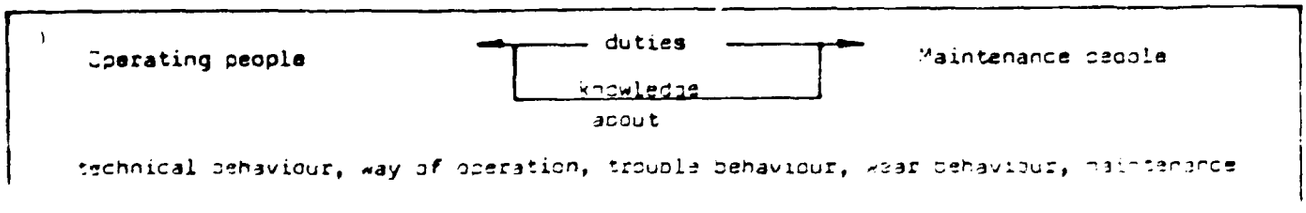
14) a)Active and b) passive protection against corrosion

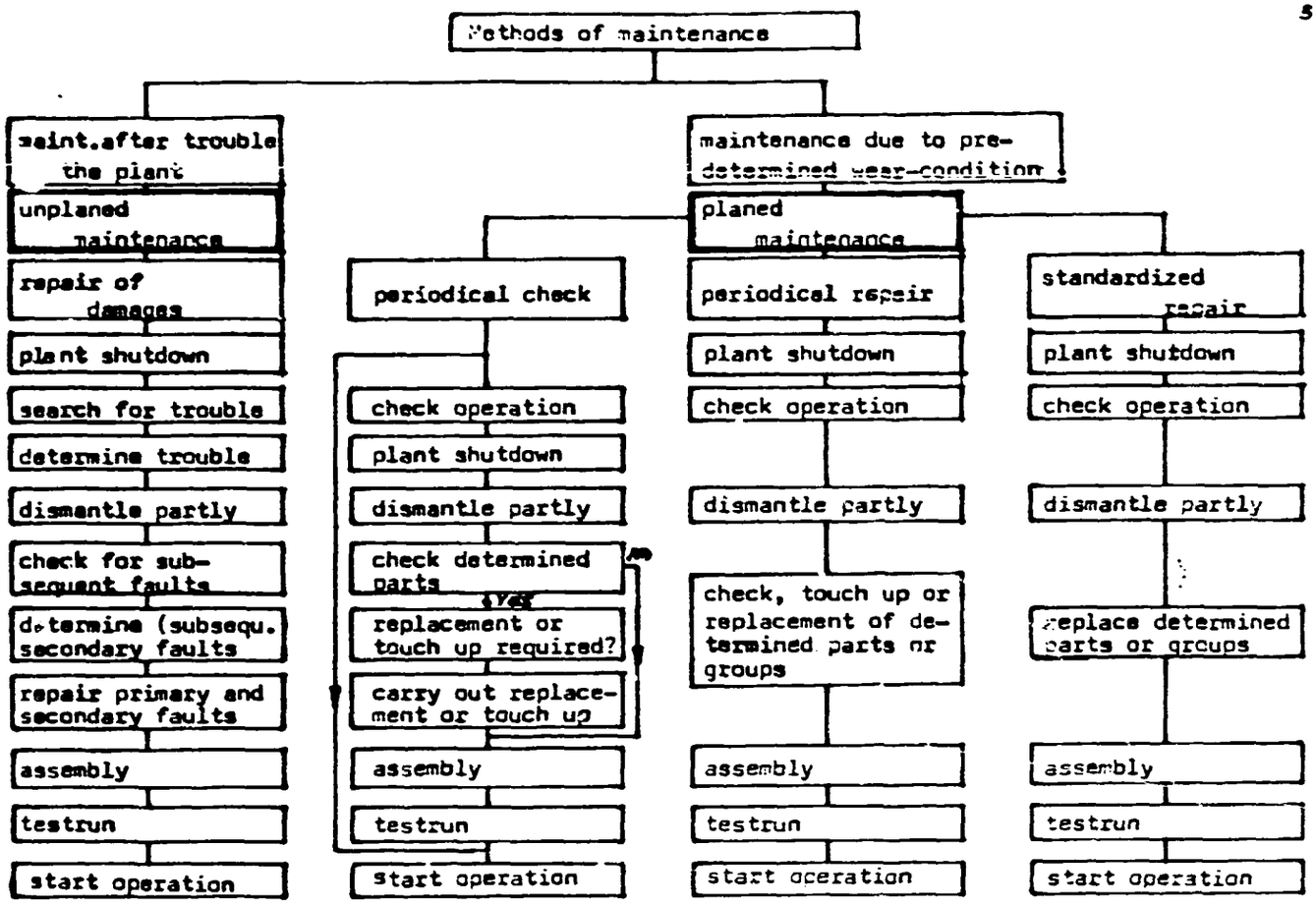
a) Avoidance of destruction

b) Building of a protective layer

15) Technologie and methods of maintenance







16) Repairs

17) Maintenance schedule

18) Preparation of maintenance

19) Maintenance
Management - Planning - Realization

20) Demand for repairs

21) Investigation of repair material

22) Planning and account control of maintenance

23) Specialization according to used machines

Buildings
Civil facilities (streets, sewage,...)
Vehicles
Hoists and conveyors
Machine tools
Tubes
Pumps, compressors, turbines,...

24) Surveillance and maintenance in chemical plants

25) Maintenance and pollution control

4. UNIDO-Workshop

LEAFLET ABOUT HANDLING OF AMMONIA

1. Properties

1.1 At normal conditions Ammonia (NH_3) is a colourless gas with a characteristic pungent odour. It is readly liguefied by cooling or compression. The liquefied Ammonia evaporates readly and fastly at atmospheric pressure. This gives rise to a strong refrigeration to 40 degrees C below zero. Ammonia is very soluble in water, the saturated solution containing 35 % NH_3.

Synonyms for aqueous solution: Aqua ammonium; Water of ammonia; Aqua ammonia; Ammonium hydrate.

1.2 Liquid Ammonia, aqueous solution of high concentration, likwise gaseous Ammonia of higher percentage have an irritating effect on the skin, mainly the genitals the respiratory tract and mucous membranes of the nose, due to an alkaline caustic action. Liquid Ammonia can also cause frostbites. The pungent odour is waring in due time.

Maximum allowable concentration in air (* M.A.C.) 50 parts per million (= TLV: treshold limit value)

1.3 Fire and explosion hazard are present but are considered small.

./2

*) M.A.C. = that concentration in a working atmosphere, of a dust, fume or vapor such that if it is exceeded, for appreciable periods, damage can be caused to the health of exposed individuals.

2. Handling

2.1 Ammonia, gas or liquid, is best removed by spraying with much water into it.

2.2 Explosive limits: 16 to 25 % by volume in air. At certain limitations (15,5 - 27 Vol% NH_3) an ammonia-air-mixture is explosive, therefore in rooms, where such mixtures might occure, the use of open fire or light, also smoking, are prohibited. In case weldings or jobs with open flames really have to be done during erection or repairing work, this is only permitted with the special approval of the management of the company under adequate supervision and observing special precautions.

2.3 Poisonousness and danger of explosion need utmost care at all jobs at containers, apparatuses, linings and fittings for ammonia (depressurizing, careful evacuation, blowing out with N_2, repeated rinsing with water, detaching and closing of the pipings) Mines and canals are only allowed to be entered with utmost care and using the suitable breathing equipment. The precautions for accident prevention of the "Berufsgenossenschaft", encl. 4, Section A are carefully to be observed.

3. Storage:

3.1 Cylinders should be stored away from heat and sunlight.

./3

3.2 They should never be dropped.

3.3 Connections to these cylinders should be tight. Caution should be observed when opening containers, and gas masks should be worn.

3.4 Recommended storage in fire-resistant structures, away from Chlorine , Bromine, Iodine and Mineral acids.

3.5 Water is an effective fire-extinguishing agent.

4. Treatment and Antidotes

If liquid ammonia is spilled upon the clothing, all clothing should be removed immediately and the body thoroughly drenched with water. If the eye is injured by ammonia, it should be washed immediately and copiously with water and this may be followed by the introduction of a saturated solution or boric acid. If pain is severe, use local anesthetic, such as 0,5 % solutions of pontocaine hydrochloride. Thereafter, the application of olive oil or some similar oil is desirable. Continuous warm boric compresses to the eyes may be of value. The usual treatment of corneal ulcers should be instituted and an ophthalmologist should be called at once. Respiratory and circulatory measures should be taken if the concentration of fumes has been severe and the respiration affected. Inhalations of from 5 to 7 % carbon dioxide in oxygen should be given and if pulmonary edema ensues, the use of oxygen by means of a tent or intranasal apparatus is advised.

5. Precautions

5.1 Ammonia vapours are lighter than air

./4

(density = 0,6 referring to air) therefore they escape overhead. Good aeration overhead has to be cared for because of this. At sudden ammonia escapes, for instance at breakages of turbines, fittings or containers, leave rooms as quickly as possible, protect mouth and nose by holding moistened rags in front of them. Even a dry handkerchief or the sleef of a jacket will do at an emergancy at fire.

5.2 Leakages can be found by searching with a wooden or glass stick, which was dipped into HCl solution of about 15 % (be careful, corrosive!) or with moistened red litmus paper; at a presence of ammonia, white mists occure resp. the litmus paper changes to blue.

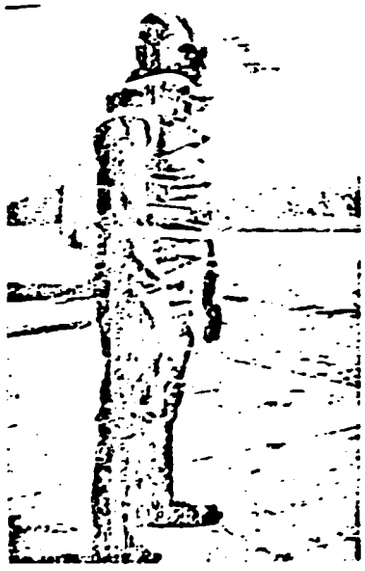
5.3 Absolute necessary jobs in ammonia poisoned rooms (for instance handling of valves, turing out of machines, saving of hurt people) only using suitable precautions, for instance:
Fresh-air-, compressed air or oxygen breathing apparatuses and use of an impervious special suit for the protection of the body (picture 1 and 2)

5.4 At the use of the oxygen breathing apparatus the filter K, identification colour green, is to be used. At the storage in rooms with normal humidity, temperature and atmosphere, the filter is durable for 3 years in an unused condition when

./5

closed by the manufacturers. After expiration of the time of storage, also unused filters are not allowed to be used any more.

5.5 At the work stronger ammoniacal water (ammonia solution) well-fitting safety-glasses have to be used, so that nothing can sprinkle into the eyes.



picture 1

picture 2

./6

6. Literature

A New Dictionary of Chemistry

ed. by Stephen Miall, LL.D.B.Sc. Longmans,
Grenn and Co., London

Römpps Chemie-Lexikon

Franckh'sche Verlagshandlung, Stuttgart Bd. 1

Ullmanns Encyklopädie der techn. Chemie

Verlag Chemie, Weinheim, Bergstr. Bd. 7

Handbook of Dangerous Materials

by N. Irving Sax
assisted by M.J. O'Merin and W.W. Schultz
Verlag: Reinhold Publishing Corporation
330 West Forty-Second St., New York 18, U.S.A.

Merkblatt über den Umgang mit Ammoniak
Berufsgenossenschaft der Chemischen Industrie
Verlag Chemie, Weinheim, Bergstr.

4. UNIDO Workshop

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Recycling

Increasing density of population, the formation of over-crowded regions, growing industries with expanding productions and finally, welfare of each people lead to an enormous burden on environment. The disposal of growing wastes of industry, traffic and homes had become a world-wide problem, which concerns each of us.

Wastes coming from industry, business and house-holds are distinguished belonging to their use in cooling waters, process waters or fecal waters. All these waters burden in various manners the waters in which they are drained off, there are rivers, the lakes, the seas and so on. In this way, the natural force of self purification is not sufficient as it is shown by many examples.

Hence, industries and public administration spend a lot of money for purifying waste waters. So the industry of Austria spent 9 billion Austrian shillings on purifying water in the years 1970 to 1980. That is 41 percent of the whole environmental expenses. To keep the quality of water in good condition or to improve the quality of it, many projects of canalisation, purification plants and control systems are realised. Chemie Linz now spends 200 million shillings on environmental purposes. 100 million shillings are related to purifying water.

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Cooling water

The water supply of the industrial plants of Chemie Linz in Linz and Enns is resulting totally from Danube water and not from underground water.

In this connection we have to emphasize that most waters in our plants are cooling waters. I think there are about 95% cooling waters. This predominating part of our water input is given back to the river as clean water which is a little warmed up by the coolers of our plants. But the warming up of our cooling water is insignificant, because waste heat is used with priority in our plant. The warming up of the Danube by our cooling water is only 0,05 to 0,1 ^{o}C. The warming up depends on the water bearing of the Danube which is various in certain limits. The legislative limit in Austria for warming up the Danube is 3 ^{o}C.

Anorganic process waters

Only a small part of our industrial water given back to the Danube is polluted. Where it is possible, all polluted waters are purified and neutralized at the origin of their formation. In our plant there are more than 100 separators and neutralisation units.

From the view of energy where it is possible process- and washing waters are recycled. In doing so, two profits are obtained : first, far ranging purification of waste waters and secondly, the production of valuable raw materials.

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In this field, Chemie Linz developed some internationally well-known recycling processes, for example, the production of AlF_3 from fluoride containing waste waters of the phosphate fertilizer production . The AlF_3 is a desired raw material for aluminium electrolysis . The know how of this process was given to many foreign countries and now there are such plants in DDR, Romania, Japan, Sweden and Jugoslavia.

Fecal waters and Industrial organic process-waste waters

It is known that organic substances from industry and households are discharged into rivers and lakes. In this waters the organic substances are eaten by bacteria , existing in the water. By this process CO_2 and H_2O are formed. This reaction is a basic reaction for natural self purification processes in our waters. This reaction can only run in the presence of a sufficient amount of oxygen. In absence of oxygen the micro-organism cannot exist. Accordingly, purification of waste waters is increasing in cases of decreasing of oxygen. Such reactions caused by micro-organism are used to purify waste waters by biological purification plants. These purification plants are installed before the waste water is running down to the rivers and lakes, so that only purified water is coming into the rivers and lakes. In the purification plant an additional effect is obtained by bringing in much more oxygen by means of mechanical treatment. Besides, with this mechanical treatment of waste waters, the arising sludge in

the biological step is recycled. In this way a purification of waste water is guaranteed and only clean water is drained into the rivers and lakes.

Regional purification plant Linz

In comparison with many other rivers in densely populated regions, the water quality of the Danube is not bad. In Austria we have water quality standards . The Danube in Upper Austria is of the class II and III of a basis of a valuation of four classes . By damming up the Danube in 1979 for erecting a water power station near Linz, now better water quality standards are required. House-hold wastes together with industrial wastes should be purified in the regional purification plant Linz. This plant can purify all waste waters of the region of Linz including industries. So the waste waters of the Chemie Linz, the VOEST-Alpine (steel works) and of the Ennser sugar industries are purified in this biological purification plant, too.

Outside of waters resulting from house-hold and business organic waste waters are coming from industry. In our plants also organic waste waters are existing. But now we are making great efforts in minimizing waste waters. Generally, people believe that only poisons are dangerous in waste waters. Admitting, poisons are very dangerous to natural self purification processes that all organic substances like unpoisoness solvents, articles of food and detergents reduce the oxygen contained in the rivers and lakes.

./5

This information should make you understand that pouring out of liquids in drain pipes in laboratories is surely not the right way of waste disposal.

In principle, all wastes should be separated from water. Furtheron, all mother liquors should be recycled and solvents should be recovered, because , as you know, the purification of waste waters in mixed and in diluted state is much more expensive and technically more difficult. Clean water is nowadays too valuable to be used as means of transportation for waste disposal.

Activities in our works situated in Enns (near Linz)

In our new plants, situated in Enns, acrylonitrile is produced. Most of the waste water is incinerated. Only a small part of waste water whose burning is not economical, has to be purified by a biological treatment.
To realize these processes it is necessary to combine recycling steps and enrichment stages by adequate energy consumption. In the past , diluting of waste waters by cooling waters was desired in order to reach lower concentrations of emission in the waters.Such a dilution of waste waters is disturbing , if a biological treatment of waste water is intended. In our plant in Enns, a special sewage system is erected to separate cooling waters from biological treatment plants.

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Recycling methods

In various points of my essay you heard of recyclings or recycle methods. As a matter of this principle, raw materials are recovered from wastes and can be used to further reactions. Nowadays, recycling is of great importance in waste economy.

In chemical industries the recycle methods have been applied long before environment protection was born. The reason for such application was to improve yields of chemical reactions. An example is the synthesis of ammonia by reacting nitrogen and hydrogen. Once, passing of the reactants leads to yields of 30%. By means of recycling yields can be increased up to 98%.

Another example is our gypsum sulphuric acid process. By production of high quality phosphate fertilizers, a great quantity of sulphuric acid is used to separate an undesired surplus of calcium from raw phosphate. By this reaction $CaSO_4$ is formed, the so-called gypsum. This waste material is utilized to a simultaneous production of Portlandcement and of high quality sulphuric acid. Sulphuric acid is recycled to fertilizer production. This recycling of gypsum prevents the formation of giant waste gypsum heaps. On the other hand, more than 100 000 tons per year of calcium sulphate can be saved from natural sources.

A further example from Chemie Linz is the recycling of lubricating oils and the work-off of fibre wastes and polyethylene wastes.

./7

These recyclings by Chemie Linz are the reason that not more than 1 % wastes are produced in comparison to the total production of chemicals. 1 % waste is a very low value in comparison to 10 % in the great chemical plants of western Germany's industry or other industrial spheres.

Removal of wastes

Removal of wastes is a great problem. Not all wastes can be carried to refuse pits. In Austria there are only a few possibilities for removal of difficult wastes. Therefore it is necessary to remove these wastes in foreign countries where they are burned in special furnaces. In our plants an organisation for wastes has been installed, it is the organisation-plan for wastes. This organisation-plan fixes each waste from production process and determines its removal or its recycling. If the way of removal is done, there exists a waste book which determines what has to be done with the wastes . In this manner all wastes are registered and their further way is determined.

It is not possible in my time to speak about all this environmental problems. It is the aim of my report to show that chemical industries are able to solve their problems of environment within a sociable limit. New technologies make it possible to realize more extensive laws for the protection of environment. The proceeded development lets us see the future with optimism. This optimism seems to be very necessary, thinking of the great problems of the future , first the growth of the world population and securing of sufficient food for people and secondly, to make a natural environment possible in the future.

4. UNIDO-Workshop

RESPOSIBILITY OF DEPT. ATH

Maintenance of the existing ammonia single-train unit and old HP-plant in the best way (good performance, low costs, short time).

Improvement and rationalisation of the different facilities and processes.

Preventing of accidents

Controll of maintenance costs

Working out of shutdown programmes

Co-operation with different departments concerning expansion of existing and installation of new plants

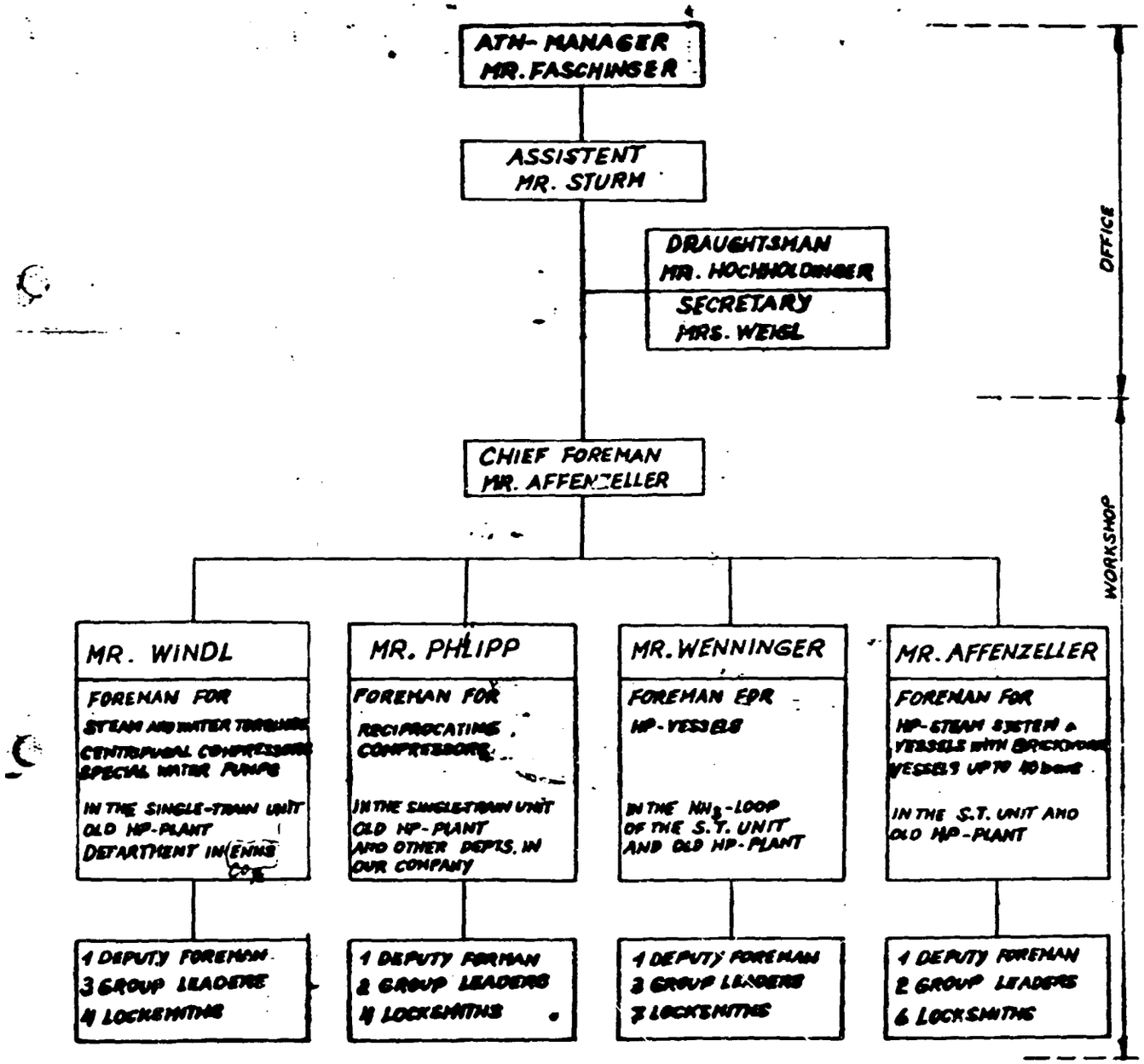
Good contact with production people and some central departments (central work-shop, electrical dept., instrument dept., civil dept., design, safety, ...)

Stand - by service from friday to monday:

1 engineer or foreman
2 locksmiths

ORGANISATION DEPT. ATH

A .... DIVISION A (AGRICULTURE CHEMICALS)
T..... TECHNIC
H.... HIGH PRESSURE PLANT



THE FOREMEN ARE ALLOCATED TO THE CERTAIN JOBS
THE WORKERS – IF NECESSARY – ONE CAN SHIFT BETWEEN THE 4 FOREMAN-GROUPS

Single-Train-Unit
Maintenance

Lay out of the unit: 240 000 t/year NH_3 resp. 850 to/day NH_3
Feb. 1975: Start up of ammonia-production.

Productions figures:

1975	200 000	t/year NH_3
1976	262 000	" "
1977	290 000	" "
1978	294 000	" "
1979	334 000	" "
1980	291 000	" "

daily production now: 1 000 t/day NH_3

For maintenance we needed:

	hours	material (Mio S)
1975	117.000	11,2
1976	84.000	5,0
1977	60.000	7,1
1978	108.000 *	10,0 *
1979	40.000	1,6
1980	90.500 **	4,8 **

*) 1978 was the 1st general revision
**) 1980 a revision for changing cathalyst in primary reformer
For this revisions we needed:

*)	67 000	7,0
**)	50 000	3,0

The investment costs for the single-trai-unit was about 500 Mio S in 1974.

On stream days:	Syn. gas production	NH_3-production
1975	280 days	217 days
1976	317 "	294 "
1977	335 "	321 "
1978	326 "	313 "
1979	362 "	355 "
1980	328 "	310 "

ATH/Fa/Wl

HISTORY OF AMMONIA PRODUCTION-PLANT (ATH)

1942: Starting of ammonia-produktion 75.000 jato N
with 4 units, each with 60 to N/day.

1966: Expansion to 300.000 to N/year

1975: STARTING of ammonia single-train unit 290 d/year
Lay out: 200.000 to N/year
1978: 242.000 to N/year, also we had a 330
general-revision for 6 weeks

Due to good operation and good maintenance the percental running time of all our facilities is very high.

(100 % = 365 days per year)

p.e.: Reciprocating compressors 99,5 %
General revision every 45.000 hours = 5 years

Main-materials used in Single-train-unit

		CODE			COMPOSITION [%]									APPLIKATION
		Mat. Nr.	internat. code		C	Si	Mn	Cr	Mo	Ni	V	Ti		examples
Normal-steel	HEAT RESISTANT	1.0305	St. 35.8		≤0,17	≤0,35	≥0,40						P,S max. 0,05	water-, gas- and steam-pipelines up to 300°C
		1.0425	H II		≤0,20	≤0,35	≥0,50						-"-	shell for Desorber, Absorber
		1.5415	15 Mo 3		0,12÷0,20	0,15÷0,35	0,50÷0,70		0,25÷0,35				P,S max 0,04	shell for secondary-reformer
		1.7335	13 Cr Mo 44		0,10÷0,18	0,15÷0,35	0,40÷0,70	0,70÷1,00	0,40÷0,60				-"-	pipes in waste-heat-system up to 550°C
		1.7380	10 Cr Mo 910		≤0,15	0,15÷0,50	0,40÷0,60	2,00÷2,50	0,90÷1,10					desulphur-reactors schell for waste-heat boiler
		1.7709	21 Cr Mo V 57		0,17÷0,25	0,15÷0,35	0,25÷0,65	1,00÷1,50	0,65÷0,80		0,15÷0,25			bolts up to 550°C
HIGH ALLOYED STEEL	HYDROGEN-RESISTANT	1.7779	20 Cr Mo V 135	N9	0,17÷0,23	0,15÷0,35	0,30÷1,50	3,00÷3,3	0,50÷0,60		0,45÷0,55			pipelines in ammonia-synthe.
				ATM NiMoV (Type VOEST)	0,15	0,33	1,40		0,47	0,66	0,12			shell for ammonia conver
	STAINLESS-STEEL	1.4541	x10 Cr Ni Ti 189	SAS 2	≤0,10	≤1,0	≤2,0	17÷19		9÷11,5	-	5 x C		pipes and vessels for corrosive mediums
			x10 Ni Cr Al Ti 3320	Incoloy 800	0,03	0,5	0,7	21,5		34		0,6	0,75 Cu 0,30 Al	lines for brickwork
STEEL CASTING		1.0619	GS-C-25		0,20	0,40	0,65	≤0,03						cases of naphtha-pump
		1.4027	G-X-25 Cr 14		0,14	0,24	0,49	13,2		0,97				cases of boiling water pum
		1.4552	G-X7 Cr Ni Nb 189		0,06	1,30	1,35	18,9		9,44			Nb 0,68	cases of Benfield-system

GENERAL DESCRIPTION MATERIALS FOR:

APPLIKATION	CODE			COMPOSITION [%]								
	Mat. No.	internat. code		C	Si	Mn	Cr	Mo	Ni	V	Ti	
(0-40bar up to 400°C)	1.0305	St 35.8										
High pressure steam lines 40 ÷ 128bar (from 400 – 525°C)	1.7335	13CrMo 44		0,10 ÷ 0,18	0,15 ÷ 0,35	0,40 ÷ 0,10	0,70 ÷ 1,00	0,40 ÷ 0,50				
x) High pressure syn. gas 0-325bar (up to 300°C)	1.0305	St. 35.8		≤ 0,17	≤ 0,35	0,40						P,S max 0,05
0-35bar (from 300-450°C)	1.5415	15Mo3										
0-35bar (from 450-515°C)	1.7335	13CrMo 44										
Primary reformer Tubes	–	GX 40 NiCrNb 3324	36X Type Pompey France	0,35 ÷ 0,45	max 1,5	max 1,5	23 ÷ 27		32 ÷ 35			P,S max 0,03%
pigtails	1.5415	15Mo3		0,12 ÷ 0,20	0,15 ÷ 0,35	0,50 ÷ 0,70		0,25 ÷ 0,35				
collector system	1.5415	15Mo3										
lines for brickwork	–	X10NiCrAlTi 3320	Incoloy 800									
Desulphur-reactors shell	1.7335	13CrMo 44										
Secundary reformer schell	1.5415	15Mo3										
lines for brickwork		X10NiCrAlTi 3320	Incoloy 800	0,03	0,50	0,70	21,5		34		0,6	0,75 Cu 0,30 Al
Steam waste recofering boiler tubes		15Mo3/Inconel 600										
tube plate	1.7335	13 CrMo 44										
shell	1.8807	13 Mn Ni Mo 54	BHW 35 Type Borsig	≤ 0,16	0,10 ÷ 0,50	1,00 ÷ 1,60	0,20 ÷ 0,40	0,20 ÷ 0,40	0,60 ÷ 1,10			P,S max 0,025
shield												
ferules		X10NiCrAlTi 3320	Incoloy 800									
lines for brickwork												
Methanreactor shell	1.7335	13CrMo 44										
Ammonia converter shell		ATM NiMoV (hydrogen resistant)	Type VOEST	0,15	0,33	1,40		0,47	0,66	0,12		
basket	1.4550	x10CrNiMoNb 1812		≤ 0,10	≤ 1,00	≤ 2,0	17,0 ÷ 19,0		9 ÷ 11		> C 8x	Nb > 8x C
High temperature converter	1.7335	13CrMo 44										
Low – " – "		Altherm 50	Type VOEST	max 0,21	0,30 ÷ 0,50	~ 1,20		0,50 ÷		0,45 ÷		P,S max 0,040%
x) High pressure synnas 325bar 280 ÷ 400°C	1.7779	20CrMo V 135	N9	0,11 ÷	0,15 ÷	0,30 ÷	3,0 ÷					

Development of Syngas-Compressors of Single-train-Plants

In the first Single-train-plants, designed by Kellog there were used syngas-centrifugal compressors which were developed by Clark. The pressure in ammonia reactor was fixed with ca. 160 bars. To reach such a pressure Clark has designed compressors with two cases. The speed was approx. 10.000 Rpm.

Improving the efficiency of ammonia synthesis made it necessary to increase the pressure in the ammonia synthesis. Nuovo Pignone, BBC, Cooper-Bessemer and Clark designed sompressors which reached a pressure of 320 bars.

One of the problems of high speed centrifugal compressors is their low weight, compared for example with receprocating compressors.

The pipelines to and from the compressor have large diameters, there exist high pressure.

Therefore it is very important to prevent forces of reaction delivering to the compressor. This is also a very important point for steam-turbines. The reaction force of steam pipelines is - caused by the high temperature of steam (500°C) - very large. In our plant we did not make good experiences with pipeline carrier with springs, because the reaction force of the spring depends on the spring-constant.

So we concepted carriers holded by weights. This kind of carriing pipelines needs more place, the advantage is to have constant forces delivered to the pipelines.

Experiences in Sealing the 4th Stage of the Syngas-Compressor

After having operated our syngas-compressor half a year we had to switch off the compressor because the oil-consumption increased. Removing the seals we noticed, that the seals on recycle-side were o.k., but on syngas-suction-side the high-pressure sealring was demaged. The white metal was melted and the O-ring was brittled.

Enclosion 1 shows how the seal-consumption increases.
In enclosion 2 the operation conditions of the seals are shown.
A drawing of the seals with dimensions shown in enclosion 3.

In enclosion 2 it is obvious that on 7.9., 9.9. and 12.9. the seal-oil-temperature TI 6025 had increased.

Except of this temperature could not be noticed any other disturbance. The result of the analysis of the residuals found on the seal ring in the case of the compressor and in the automatic oil-separator was, that the residuals were no coke-products of the oil.

The residuals (zincdithiophosphate) are caused by connection of oil with ammonia at the existing high pressure.

After having repaired the compressor we had a seal consumption between 1 and 5 litres per day.

The brittled O-ring material was viton. But viton is not resistant against ammonia and we changed it to Silikon with success.

To avoid a arise of zincdithiophosphate Nuovo Piguone had made following arrangement:

./2

1. To install a connection between syngas-discharge and balance-gas.

2. The pressure in the balance-gas should be holded about 0,5 - 1 bar higher than the syngas suction pressure. Through this improvement the pressure of ammonia in Reference-pipe is reduced.

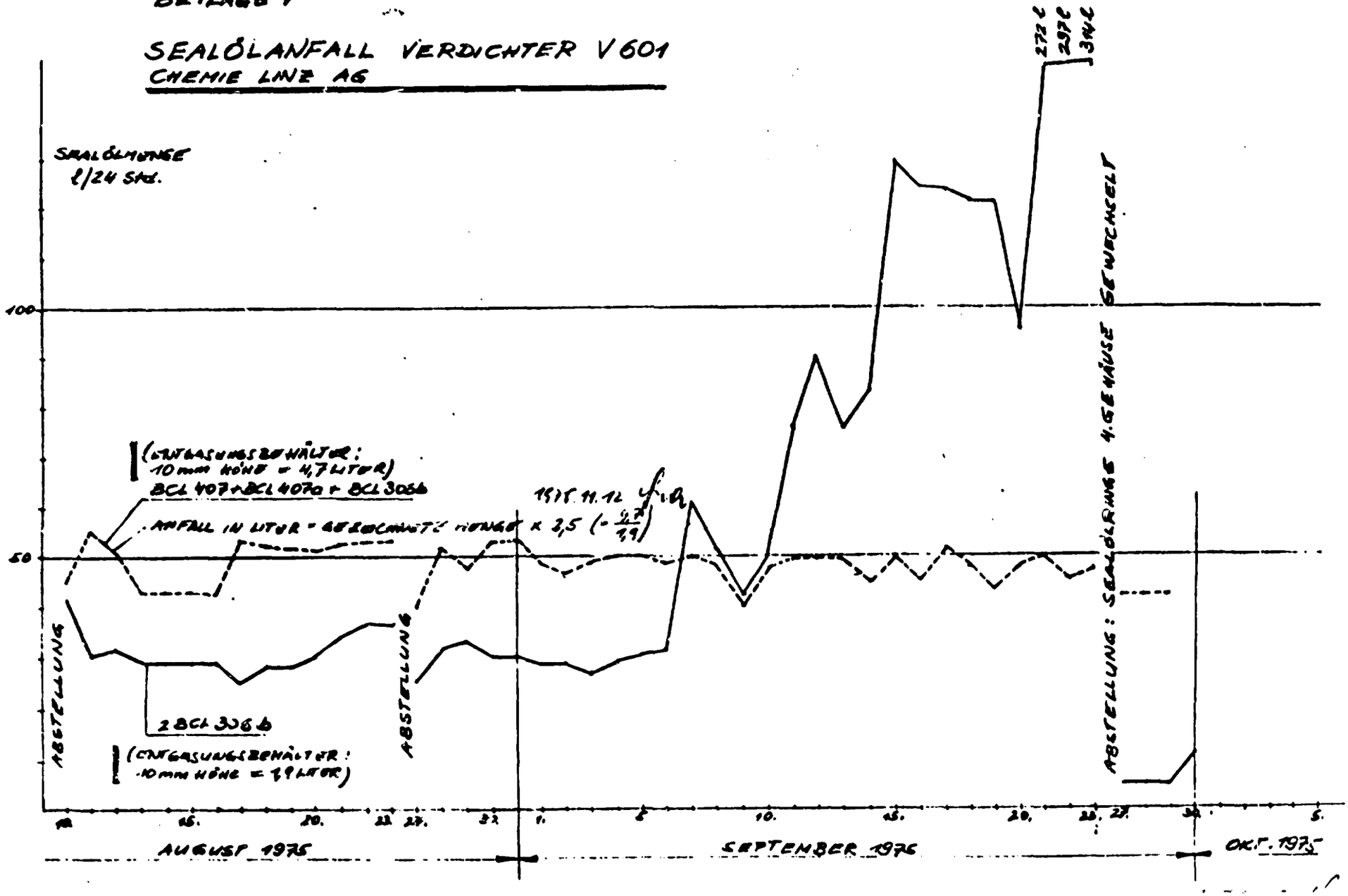
   After having installed this connection-pipe we did not have any difficulties with the seals of the 4^{th} case. It is to take care that the Quenchgas in the connection-pipe has a temperature lieing higher than the dewing point of the gas.

   If the temperature is below dewing point the labyrinths could be demaged by erosions.

   The arrangement of the Quenchgas-pipe can be seen in enclosion 4.

BEILAGE 1

SEALÖLANFALL VERDICHTER V 601
CHEMIE LINZ AG



BEILAGE 2

BETRIEBSZUSTÄNDE VERDICHTER V 1501 (4. GEHÄUSE - 28CL 3066)

TAGESMITTELWERTE

DRÜCKE IN bar, TEMP. °C

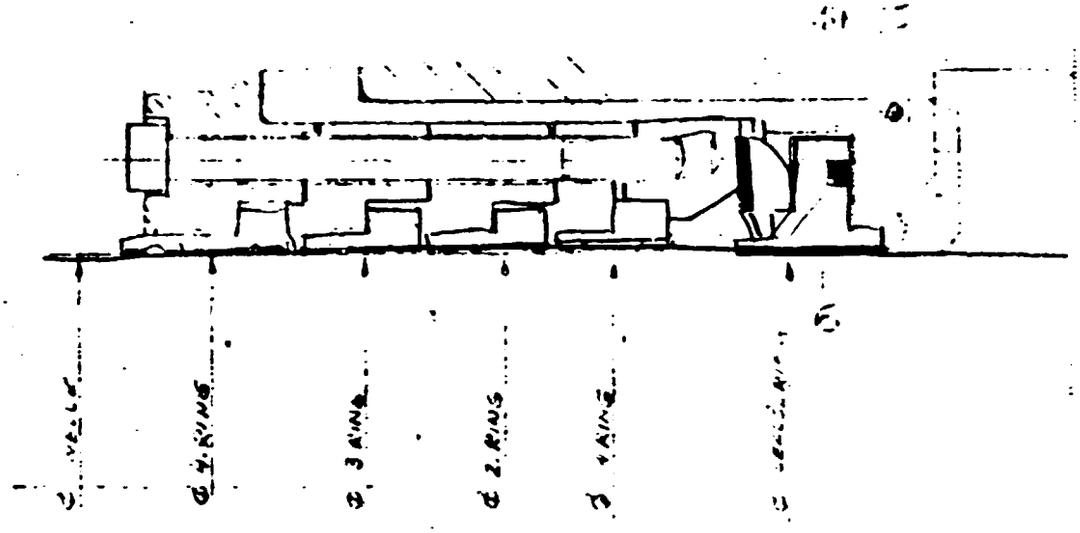
	ANLEGESTELLE	DATUM 09.03	09.04	09.05	09.06	09.07	09.08	09.09	09.10	09.11	09.12	09.13	09.14	09.15	09.16	09.17	09.18	09.19	09.20	09.21	09.22	09.
TEMP. EINGANG 4. St.	T 607	26	26	27	26	25	27	27	26	26	26	27	27	27	27	27	27	27	28	28	27	2
DRUCK AUSGANG 4. St.	P 607	257	255	260	260	255	258	257	250	250	254	252	255	251	250	248	250	250	255	252	248	25
TEMP. AUSGANG 4. St.	T608/T646	31/83	31/82	34/83	31/83	31/82	34/84	31/82	30/82	30/82	31/84	32/84	32/84	32/84	32/84	33/85	32/85	32/83	34/84	34/84	33/82	33/
DRUCK EINGANG RECYCLE	P 626	260	253	255	260	265	260	258	250	248	255	250	255	251	250	245	250	246	256	250	248	2
TEMP. EINGANG RECYCLE	T 609	20	21	21	21	20	20	20	20	20	20	20	20	20	20	20	20	20	20	21	20	
DRUCK AUSGANG RECYCLE	P 609	271	268	265	270	265	270	265	256	258	268	260	265	262	260	255	250	255	265	260	256	2
TEMP. AUSGANG RECYCLE	T 610	28	28	29	28	27	28	27	27	27	27	27	27	27	27	27	27	27	27	27	27	2
TEMP. TRAGLAGER 4. St.	T626/T627	66/62	66/62	66/63	66/62	65/61	66/62	65/61	65/61	65/61	65/62	66/62	66/62	66/62	66/62	65/61	65/61	65/62	66/62	66/62	65/62	66
TEMP. DRUCKLAGER 4. St.	T 631	67	66	67	67	67	67	66	66	66	66	66	66	66	66	66	66	66	68	68	67	6
TEMP. TRAGLAGER 4. St.		73	72	73	74	72	73	73	72	72	73	72	72	73	72	73	72	72	73	73	73	7
TEMP. AXIALLAGER 4. St.		72	72	72	72	72	73	72	71	71	72	72	72	72	72	72	72	72	73	73	73	7
TEMP. SEALÖL DRUCKS.	TI 6024	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	85	85	85	8
TEMP SEALÖL SAUGS.	TI 6025	89	89	89	89	84-89	90	89-92	90	90	84-93	92	92	93	92	93	93	92	93	93	93	9
ÖLDRUCK TRAGLAGER A	P 623	1,85	1,85	1,84	1,84	1,85	1,84	1,84	1,85	1,85	1,85	1,86	1,85	1,86	1,86	1,86	1,84	1,84	1,83	1,83	1,83	1,
ÖLDRUCK TRAGLAGER B	P 6059	1,52	1,50	1,50	1,50	1,51	1,50	1,50	1,51	1,51	1,50	1,52	1,52	1,51	1,51	1,51	1,51	1,50	1,48	1,49	1,50	1,
ÖLDRUCK AXIALLAGER	P 6024	1,66	1,65	1,64	1,64	1,64	1,64	1,64	1,65	1,65	1,64	1,65	1,65	1,65	1,64	1,65	1,65	1,65	1,65	1,65	1,65	1,
SEALÖLDRUCK	P 6038	190	190	190	190	190	191	191	185	186	189	188	189	190	190	186	189	185	191	189	188	1

BEILAGE 3

STOPFBÜCHSE VERDICHTER V 601 - 2[illegible]

EINBAUMASSE (NACH REPARATUR)

WECHSEL DER SEALÖLRINGE AM 25.8.1975
NACH 1018 BETRIEBSSTUNDEN



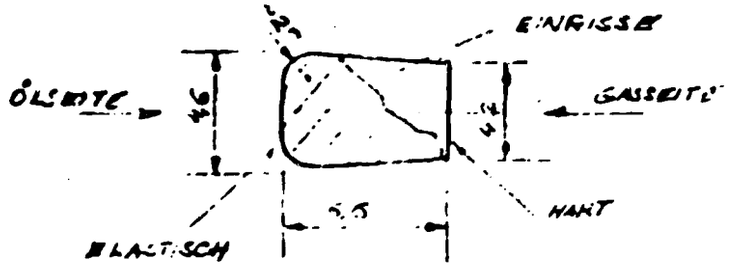
SAUGSEITE (AXIALLAGER)	34,00	34,15	34,15	34,15	34,14	[illegible]
DRUCKSEITE (KUPPLUNG)	34,00	34,15	34,15	34,15	34,15	[illegible]

FESTGESTELLTE MÄNGEL:

1) WEISSMETALL VON SEALÖLRING (TEIL 6) [illegible]

2) ABLAGERUNG VON ÖLKOHLÄHNLICHEN [illegible] SEALÖLRING, DEM VERDICHTERGEHÄUSE, DEN AXIALLAGERN UND IM SEALÖLABSCHEIDER.

3) O-RING (TEIL 45) AN MEHREREN STELLEN DURCHGE[illegible] UND AUF GASSEITE VERSPRÖDET.
PROFIL DES O-RINGES:

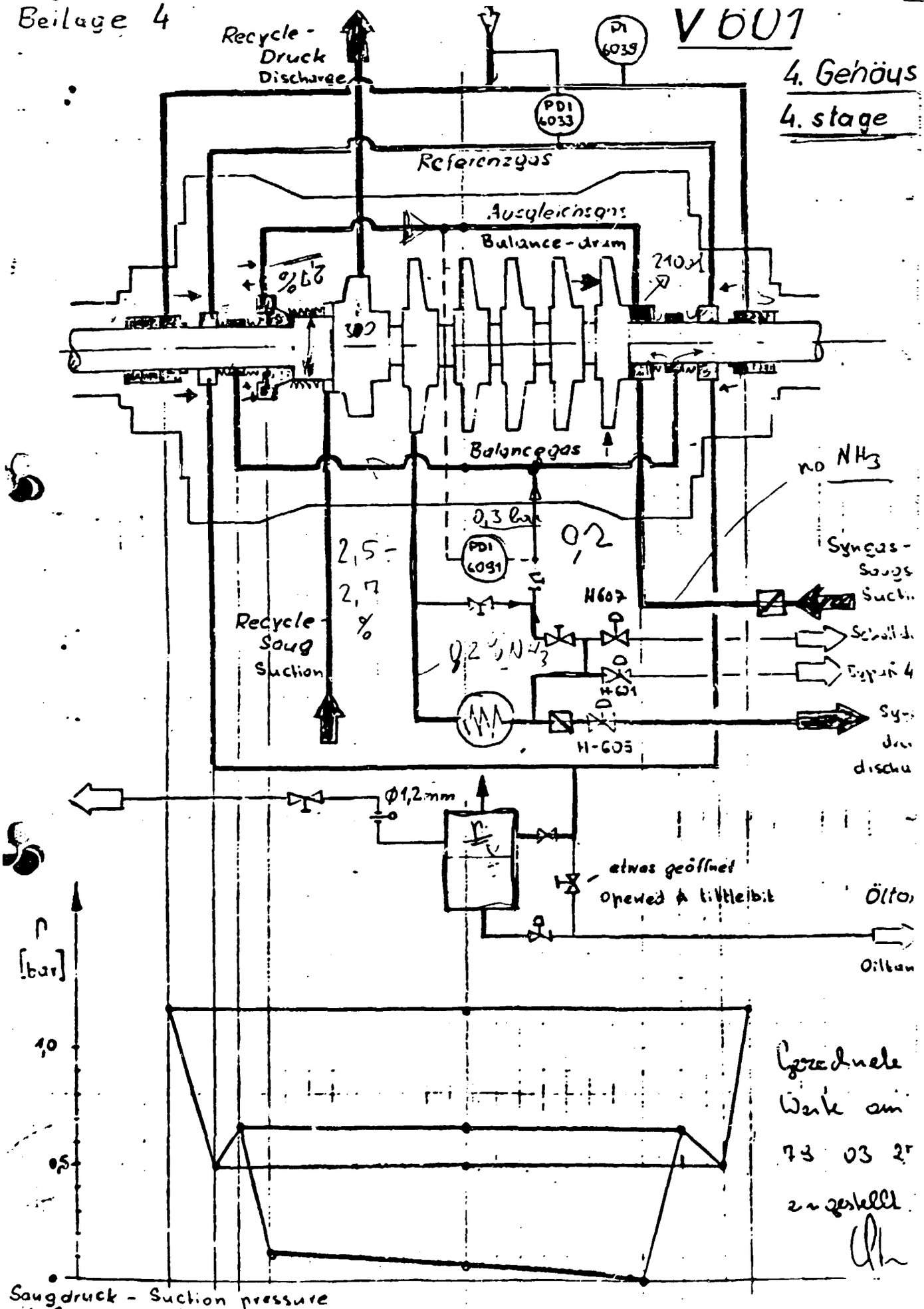


CHEMIE LINZ AG	[illegible]	[illegible]	[illegible]

Beilage 4

V 601

4. Gehäus
4. stage



Typenuele
Werk am
73 03 2
zusgestellt

Technical Experiences in the Benfield System

1. Low-Pressure-Pumps P 401/402 for Benfield Solution

Starting our plant we noticed that the low-pressure-pumps developed a noise. We suspected the reason for this noise to be cavitation.

Although we checked the pump in presence of an expert of Worthington, we could not find any indication of cavitation.

We insisted on the warranty to be prolonged for one more year by Worthington.

Worthington's expert agreed to it and explained the noticed noise with circulation.

Before the prolongered time of warranty was elapsed, we checked the impeller once again very exactly but there was not found any indication of cavilation.

When we had to change the sealrings three months later we noticed the first indications of cavitation - the back of the blades were bitten.

Steps for solving this problem

a) Welding the bitten surface with electrodes consisting of hardfacing alloy.

b) Introduction of 3 - 4 m^3/h Nitrogen into the suction pi pe of the pumps.
   - We have two low pressure pumps for Benfield solution.

./2

In the suction pipe of one of these pumps there are two ellow pipes. At this pump we found cavitation only on one side of the double flooted impeller.

The suction side of the second pump is connected with a T-part fo the main suction pipeline.

At this pump we indicated cavitation on both sides of the impeller after only 4 200 working hours.

Our engineering firm, Fa. Uhde, found out, that the noise of the pump disappeared by operating the pump with 115 % of the normal flow capacity.

By reducing the flow capacity the noise increased. This symptom was also an indication that the noise was caused by circulation.

2. High Pressure Pumps P 403/404

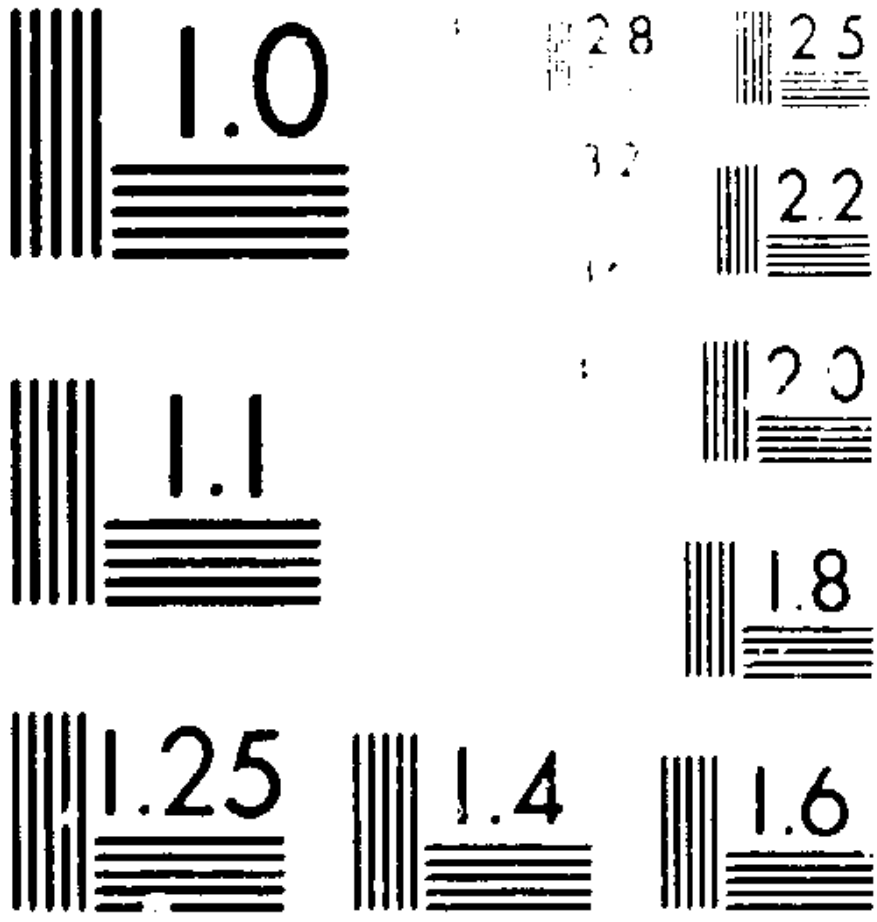
By washing and cleaning of our plant during the start up the seals were contaminated with dirt. So we had to change this part from time to time.

Having started the plant it was not necessary to change the packings for about one year. But after this time we had a lot of problems with the Pacific-seals. Sometimes we had to change the rings already after one week.

We found out that we got spare rings from Pacific, that were not flat and full of cracks.

Till this time the sealrings were greased with Benfield solution. Having such a lot of problems with seals we changed the medium for greasing the sealrings and used condensate with a temperature of 65 ^{o} - 70 ^{o}C.

./3


1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

Condensate of such a temperature is more qualified for greasing seals than Benfield solution.

The pressure of the condensate has to be a little bit higher than the suction pressure of the pump.

To make this improvement it was necessary to install a condensate cooler and a controlling system.

Since we operate with this modification the seals have to be changed approximately once a year.

3. Efficiency of the CO_2-Removal-System

After having started our plant we did not obtain the efficiency of gas purification guaranted by Uhde. After a lot of difficult examinations we found out that the bad distribution of potossium carbonate solution was the reason for our problems.

By installing leading plates we improved the distribution of Benfield solution to the ceramic intalox.

The efficiency of purification increased after this modification.

Finaly we installed two redistributers in our absorber and reached the design efficiency.

Operating Instruction V 103

for a vertical, double working reciprocating compressor, with two cranks, compressing gas in two single stages.

The operator must be well instructed about the function of the compressor.

A Design Dates

Media:	natural gas
Flow rate:	37 000 Nm^3/h
Suction pressure:	20,9 barü, can be variated
Discharge pressure:	46 barü
Speed:	495 U/min
Controlling system:	automatic reverse flow regulation to 50 % of design gas flow.

B Starting up of the Compressor

1. Inform the central comando station of our company about the start up of the compressor. Between two starts it's necessary to wait 20 minutes after the first start, because during start of the motor coils are heated.

2. Open the cooling water main valve and also valves for the cooling system of the different parts of the compressor. (Seal packings, cylinders, oil-cooler).

3. Check level of oiltank. If oil temperature is below 10 °C, it is necessary to heat up with steam.

4. Start auxiliary oil pump and check oil pressure. (minimum 2 barü)

5. Open valves in suction pipeline and in bypass pipeline. Check the suction pressure. With regard to the rate of suction pressure see point C 1.

6. Drain the condensate separators F 103 and F 104 (separator in front of the compressor anf after bypass-cooler).

7. Open valves in discharge pipeline.

8. Start the motor and observe the oil-pressure.

9. Switch off the auxiliary oil pump and check the oil pressure once again.

10. If everything is o.k., the compressor is charged by slowly closing the bypass-valve and by means of the reverse flow controlling system.

C Operation of the Machine

1. It is very important to take care that the difference in pressure between discharge ans suction is not higher than 27,4 bars.

   Therefore it is necessary to adjust the discharge pressure in dependance of the suction pressure. For example: if the discharge pressure is 44 barü the suction pressure may be 16,6 barü as minimum.

   The suction pressure should not be less than 8,8 barü, in this case the maximal discharge pressure is 36,2 barü. The suction pressure should not be higher that 27 barü, it is important that this maximum pressure is not reached.

./3

2. Following points have to be checked periodically and must be written in a operating book for instance every hour:
   a) Suction pressure (Safety valve is set at 30 barü)
      Discharge pressure (" " " " at 46 barü)
   b) Oil pressure after cleaner
   c) Oil temperature after oil cooler
   d) Temperature of discharge
   e) " " compressor bearings
   f) " " motor "
   g) " " motor coil
   h) " " cooling air to the motor
   i) " " cooling air from the motor
   j) current consumption of the motor.

3. During the inspection round every two hours following points are to be checked:
   a) Seal packings for tightness
   b) Draining of separator F 103 and F 104
   c) Compressor for knocking, grumbling and unusual noise of the valves.
   d) Level of the oil tank.

4. Cooling water flow rate is to be adjusted not to pass a maximum temperature of 45 ^{o}C outlet.

5. The compressor is to be switched off immediately if
   a) a bearing or a seal packing is overheating or if a seal packing is leaky.
   b) pressure of lube-oil is less than 1,5 barü
   c) suddenly a knocking noise is heared or if the valves operate not properly
   d) a safety valve does not close after blowing up.

./4

D Switching off the Compressor

1. Switch off the motor
2. Close valves in discharge pipeline
3. Close valves in suction pipeline
4. Close cooling water main valve
5. If necessary, purge compressor with nitrogen.

E General Maintenance

Crankcase is filled with oil, type Mobil oil extra heavy with a viscosity of 60 - 83 c St at 50 °C temperature. Oil leakages have to be compensated with the same oil type. If the compressor does not operate for a longer periode, the compressor must be turned by hand once a day. Before doing that the auxiliary oilpump has to be switched on.

D A T A V 103

Important: The difference in pressure between suction and discharge may not higher than 27,4 bars.

	Pos. Nr.	Operate range	Alarm/shut down
Suction pressure	PIALLHSL 120	see point C 1	high: 18/10 barü low: 28/- barü
Discharge pressure	PIAHHSH 119	max. 44 barü	45/52 barü
Temperature of discharge	TIAH 110 TIAH 116	max. 110 °C	130/- °C
Oil pressure after cleaner	PIALISL 113	2 - (3) - 4,2 barü	2/1,5 barü
Instrument air pressure	PIALSL 221	7 - 7,5 barü	4/4 barü
Oil temperature after cooler	TIALH 113	25 - 40 °C	low: 18/- °C high: 50/- °C
Temperature of compressor bearing east	TIAHHSH 107	45 - 65 °C	70/80 °C
Temperature of compressor bearing west	TIAH 111	60 - 70 °C	75/80 °C
Temperature of cooling air to the motor	TIAH 101	5 - 35 °C	40/- °C
Temperature of cooling air from the motor	TIAH 102	25 - 60 °C	65/- °C
Temperature of motor bearing	TIAH 106	40 - 65 °C	70/- °C
Temperature of motor coils	TRAH 104	60 - 90 °C	105/- °C

ABSTELLUNG Juni/Juli 1970

Drawing up a Programme of a General-Revision of a Single-Train

1. Operating our plant, all technical defects and leakings are registed in a booklet. These defects do not make it necessary to turn off our plant, but during the next standing all these defects must be repaired.

2. The technical department puts up the programme for the revisions of tanks, boilers, coolers, etc. which have to be done.

   In a discussion with the TÜV (technical inspection department) and the material testing department there is fixed the class of inspection.

   The technical department is also responsible for the inspection of the machines. Generally there is to say that a machine which operates normaly should not be opened.

Before deciding to open a machine or not two considerations should be done:

a) By measuring the efficiency it is possible to recognize a defect or a wear for example on the labyrinths or on the balance drum.

b) Comparing the operate dates with the dates after first starting up the machine there also can be drawn conclusions about condition of the machine.

   Therefore it is very important to regist all dates that are taken after first start up very exactly.

   The particular works which have to be done are ordered in groups (from 100 to 700, see enclosure).

./2

Every work must be valuated in regard to lenght and to the number of required workers by a foreman. Afterwards must be made a time-table which shows the number of the necessary and disposable workers.

GROUP 100

O-101 Heater for heating naphtha or natural gas.
Open and close manhole cover.
Inspection of the protect iron-bars of the burners.

W-101 Nitrogen preheater
Open lid for official inspection

G R O U P 2 0 0

W-202 II, W-208 III, W-210 Superheater for high pressure steam

Pressure check.

W-207 Superheater for medium pressure steam

Pressure check.

W-209 , W-211 Heater for prozess air

Pressure check

V-202 , V-203 Combustion air blower, flue gas blower
Cut out the shaft-cover-sheet for oil level inspection glass and for grease nipples.
Inspection of the guide blade-bearings

O-201 Primary reformer
Open two of the collector pipe-covers, check and close.
Open manholes , inspect chamotte cover .
Clean flue-gas-channel

O-204 Additional heating for waste-gas
Open manholes, inspect chamotte cover

O-202 Additional vessel
Inspection and cleaning of inside.
Repair combustion air heat-exchanger (No. 4 is blocking) .
Inspect wall at inspection hole. Clear lubrication pipes.

Combustion air and waste gas duct

Inspection and cleaning

B-210 Mixing station for steam and natural gas .
Inside inspection and check natural gas baffle

W-215 Water preheater
Remove heat-change pipelines for inside inspection.

B-208 Relieftank
Open handholes, blind off, official inspection

B-203 Degasifier tank
Widen passage for L-206 (Level controller)
Check shower (System Stork) and change T-parts.

B-209 Instrument air tank
Inspection and cleaning of tank and level controller

./3

P-207, P-208 BFW-Pumps
Clean filter . P-208 : Change flange of valve for minimum load pipeline

T-203 Turbine for P-207
Repair oil-leakage of clutch-cover
Change insulation.

B-212 Natural gas mixing station
Remove and inside inspection.

K-201 Secundary reformer
Open for changing air nozzle.

W-201 Process gas heat exchanger
Open both manhole covers. (Gasket of the hot manhole is not tight)
Cleaning and inside inspection.

W-203 BFW-preheater
Change pipe bundle, inside inspection
Change drain valve. Installing test-blades.

B-201 Steam boiler
Open and inside inspection . Pressure check
(Pressure check also for No. 4083 and 4162 - support system)

T-201 Turbine for process air compressor

./4

Inspection of the rotor . Repair oil leakage of the compressor-side clutch cover.

Repair seal packing of control-valve and the leakage of the pipeline for the pressure-indicator of the injector ; the idling-device does not function properly

W-204 Condenser for T-201
Open flange and inside inspection .
Repair cooling-water pipe to the condenser

V-201 Process air compressor
Check low-pressure and high-pressure rotor . Gearbox-side high-pressure rotor bearing is leaking. Clean air-cooling of low-pressure compressor. Change cooling-water valve for 4. stage. Check non return-valve.

W-214 Process-air-cooler
Inside inspection, also for condensed water tank and level controller.

T-202 Turbine for generator
Repair seal box of steam entrance valve

T-204 Back-pressure-turbine for generator.
Repair seal box of steam valve

G R O U P 3 0 0

W-301 Gas heat-exchanger
Pressure check. Repair leaky head-gasket.

K-301 NT- CO- Converter
Official inspection, manholes to be opened in service.
Change nozzle for condensate

W-302 , W-303 BFW-preheater
Official inspection . Repair baffle T-310

K-302 Low temperature-converter
Open man holes to change catalyst.
Official inspection.

G R O U P 4 0 0

K-401 Absorber
Open manholes, remove ceramic intalox and inspect inside. Install redistributers. Revision of the level controller.

F-403 Lye separator
Open for official inspection . Revision of the level controller.

W-401 Steam generator
Open for official inspection (inside revision and pressure check)

W-402 BFW-preheater
Remove heat-exchanger. Pressure check (2x)

W-403 Reboiler
Open for official inspection (inside and pressure check)

W-404 Benfield solution air cooler
Remove distribution pipe, pressure test.

W-408 BFW-cooler
Remove bundle (inside inspection)

./2

B-404 Relieftank
Open manholes for cleaning and inspection.

F-401 Condensate separator
Open manholes for cleaning and inside inspection.
Official inspection for level controller.

F-402 Condensate separator
Open manholes for cleaning and inside inspection.
Change draining valve. Official inspection
of level controller.

F-406 Lye double filter
Inside inspection. Grinding 4-way valves.
Change valve in the pipeline to the filter
(valve case is corroded)

K-402 Desorber
Open manholes for inside inspection and cleaning.
Repair corroded pipeline to P-405.
Install PV/H- 411 and PV/H- 412 in
pipeline-system .

F-407 Injektor :
Control injektor nozzles and valves.

W-406 BFW-preheater
Change pipelines of BFW-system.

./3

T-401 Benfield solution turbine
Seal bearings of guide-blades .
Change pipelines for greasing seals with condensate of T-401 and high-pressure lye-pump P-403.

G R O U P 5 0 0

K-501 Methane generator
Open manholes for inside revision

F-501 Condensate separator
Open manholes for inside revision and also revision for level controller.

W -501 Gas - Gas heat exchanger
Remove heat-exchanger for official inspection and pressure check.

W-502 Boiler
Open for cleaning and inside revision

W-503, W-504 final gas cooler
Open for cleaning and official inspection.
Welde in a valve in cooling-water-pipeline.

G R O U P 6 0 0

T-601 Syngas-turbine

Inspection of condensation-turbine-rotor and of the condenser.
Repair decreased cooling water pipe.
Check start-up equipment and adjust it.
Change prepared oil pipelines .

V-601 Syngas-compressor

Inspection of bearings, seal-system and rotors of case 1 - 4.
Install capacity flow measuring nozzles in balance-drum-pipes of stage 2 and 3 (F-6006 and F-6007)
Change gas-cooler
Official inspection of separator F-606 (also level controller) , F-601 , F-602, F-603, F-605, seal oil tanks No. 4054 - 4057 , level controllers 4156 and 4157 , and separators 4208 , 4058 and 4059.
Install valves in seal-oil pressure pipes of seal-oil pumps.
Change oil-filters and cleaning oil-heaters.
Change one of the oil-cooler bundle and clean the other one .

O-701 Start-up-heater

Inspect supports, pressure check

./2

W-701 Waste-heat-boiler
Open "Brettschneider" gasket. Official inspection pressure check.

W-708 BFW-preheater
Open "Brettschneider" gasket (seal ring is leak)
Official inspection, pressure check.

B-701 NH_3-expansion-tank.
Open tank for cleaning and official inspection.

B-706 Mixing-station
Remove for inside inspection.

F-701 NH_3-separator
Open lids and remove pipelines to the separator.
Clean and inside inspection.

F-702 NH_3-separator
Open lids and remove pipelines.
Clean and inside inspection.

W-703 Gas-cooler
Remove elbows of two of the five coolers.
Pressure check on this coolers.

W-704 Gas / gas-heat-exchanger
Open flanges and remove bundle. Cleaning and inside inspection.

W-705 Freezer
Remove flanges for inside inspection.

4. UNIDO-Workshop

Plants, Affairs and Competences of Dept. ATG

107, 146	Old and new waterworks (river water, cooling water supply)
140	Chlorination station for well water (0,7 ÷ 0,8 mg Cl/l H_2O)
144	Shallow well (horizontal filter tubes, well shaft, pumps)
204	Air dividing plant (2 units, each 1 700 Nm^3/h O_2), compressed air supply
204 a,b	Bottling of oxygen and compressed air
206, 209	N_2-gasometers (2 000 m^3, 500 m^3) gas-
207	O_2-gasometer (10 000 m^3) holder
208	Cracked gas (N_2 + H_2) - holder (25 000 m^3)
R.-Br.	Pipe bridges
RN	Network of pipes, piping of: KOG, natural gas, heating gas, cracked gas, steam 25, 20, 7, 2 bar, compressed air, river-, well-, hot (90°C)-, warm (40°C)-, drinking-water, boiler feed water, condensate, oxygen

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Machines, compressors and pumps in dept.-area (except standard pumps)

./2

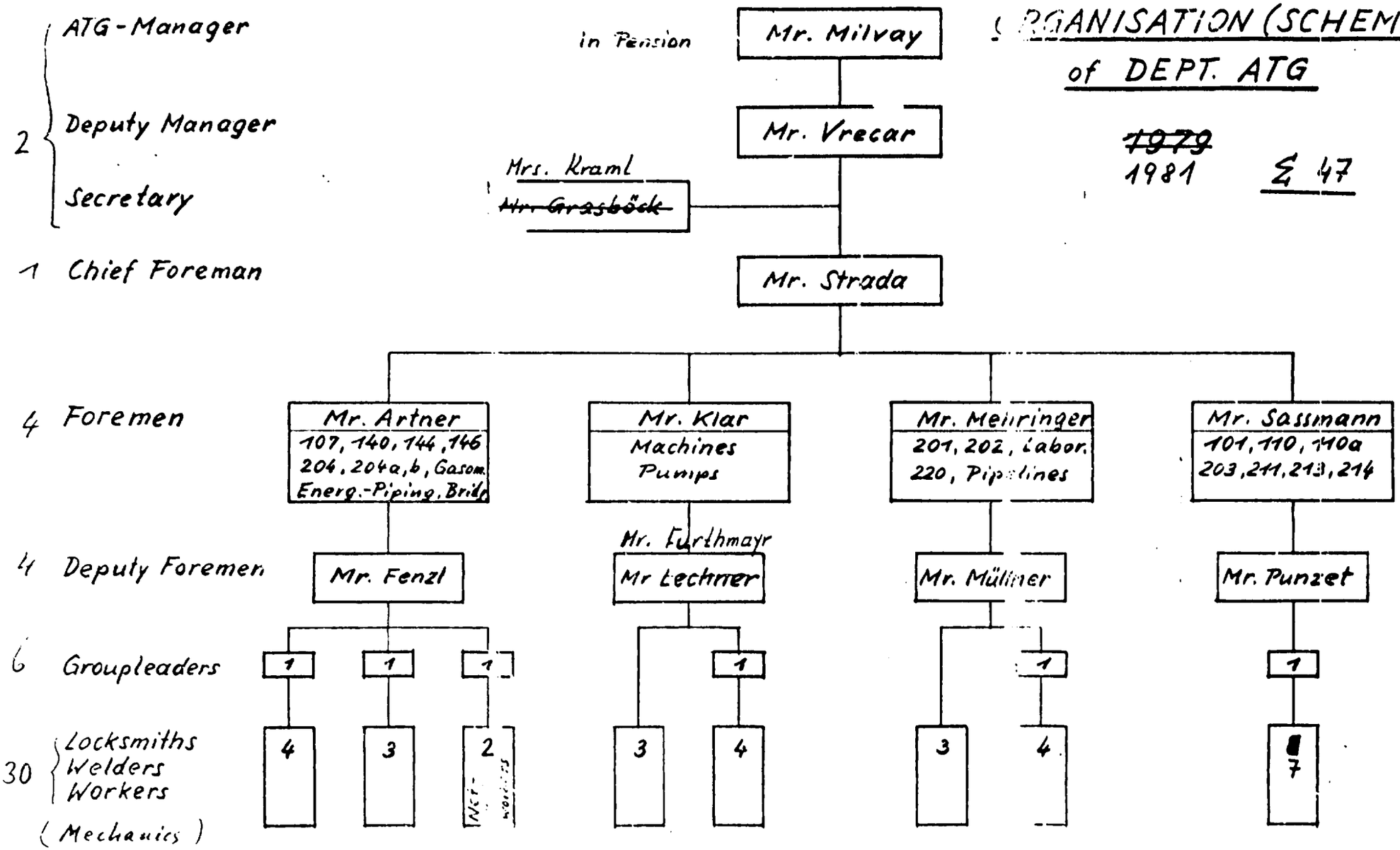
201	Desulphuration of KOG
212	Battery (block) of bottles for high-pressure N_2
202	Old gas dividing plant (reforming plant)
220	Naphtha and Orthoxylol storages and pump stations

Pipelines for naphtha and orthoxylol

101, 211	Natural gas pressure reducing stations
110	Old boiler house (2 units, each 12 t/h steam 25 bar)
110 a	Contact mud circulation reactors (flocculators)
203	Boiler fee water treatment
213	Naphtha feed water storages
214	Naphtha - steam - reforming plant (ICI-plant)

ORGANISATION (SCHEME of DEPT. ATG

~~1979~~ 1981 Σ 47



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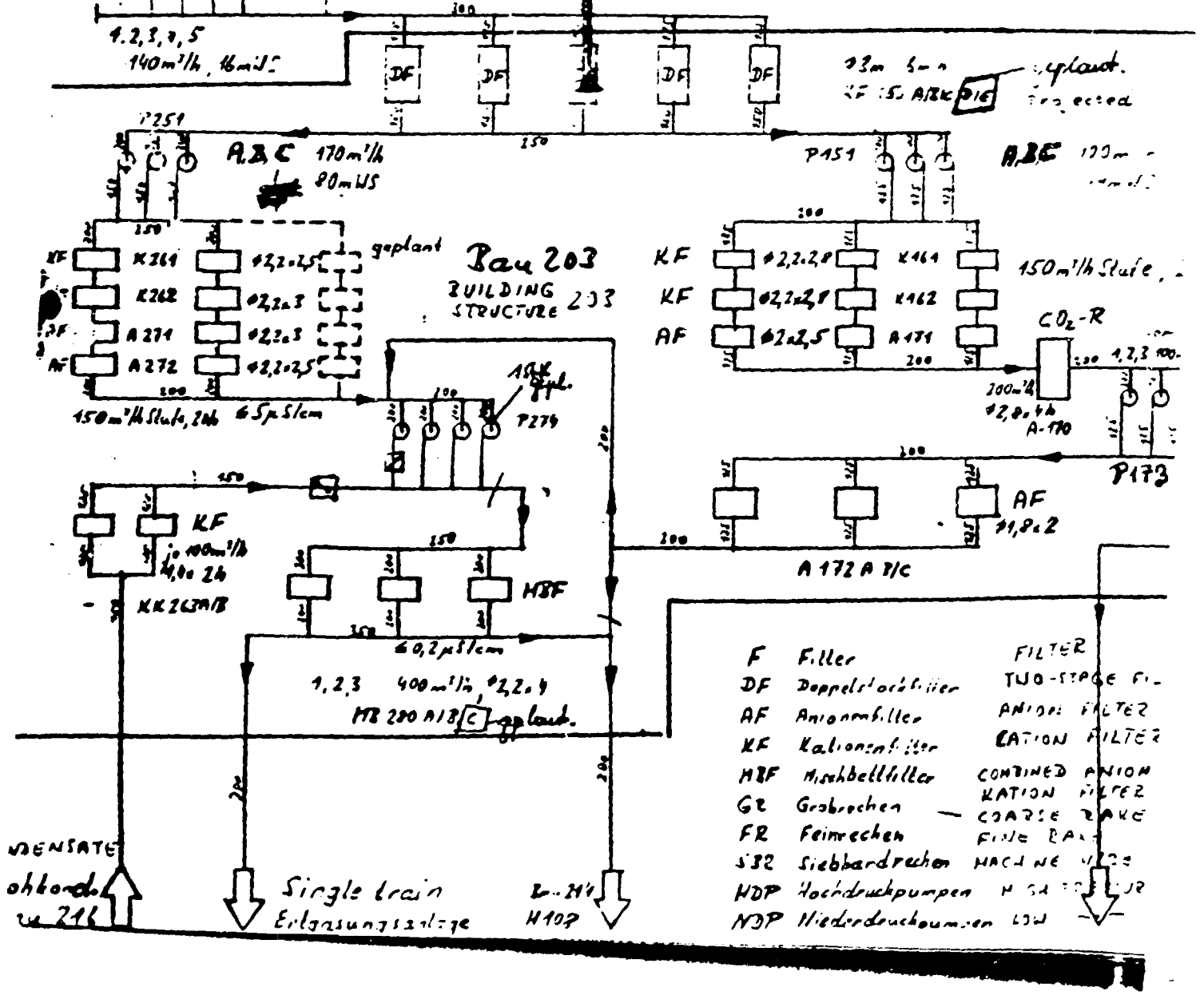
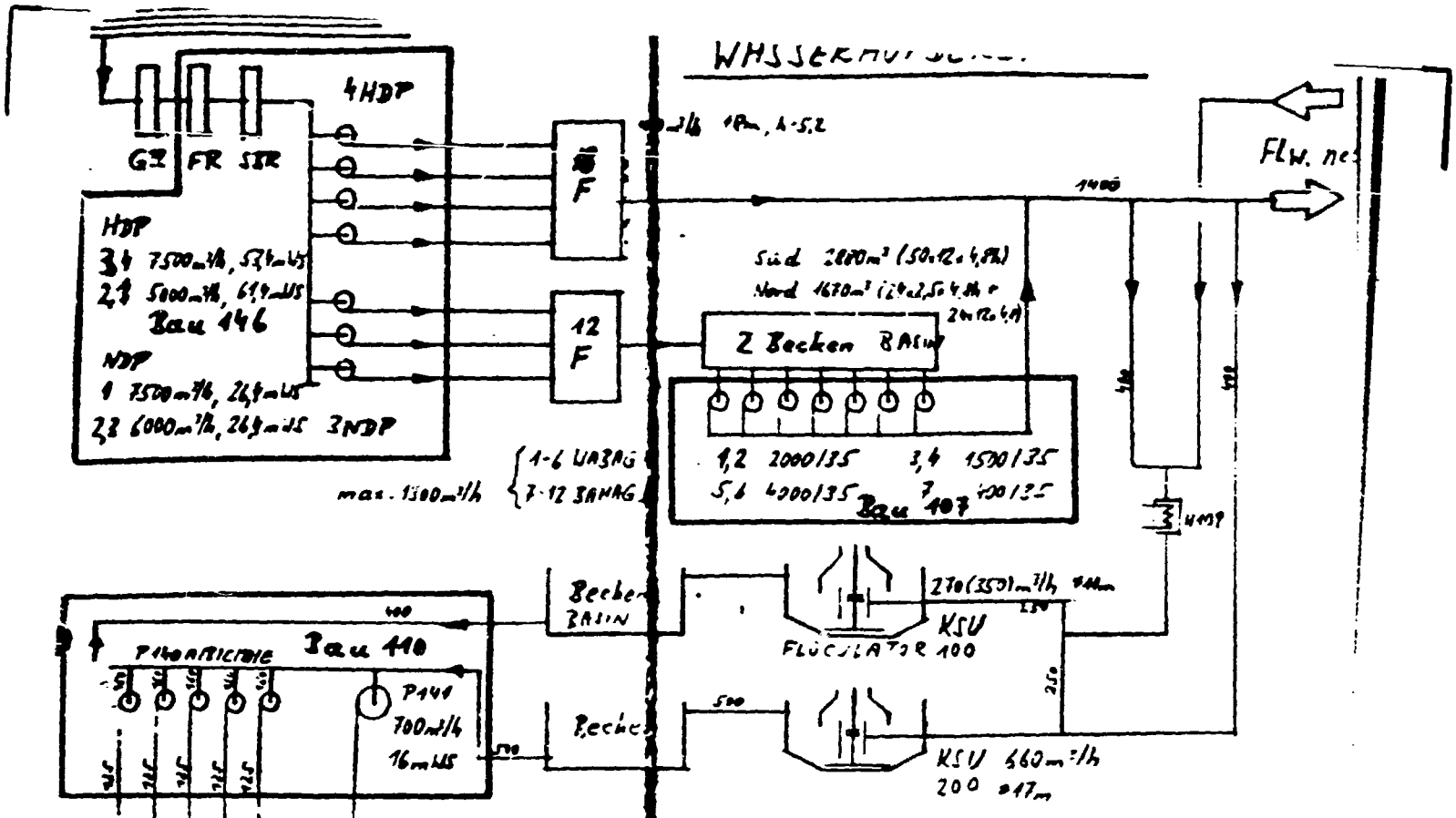

Bau 203
BUILDING STRUCTURE 203
geplant
1, 2, 3, 4, 5
140 m³/h, 16 m WS
DF
P251
A B C 170 m³/h
80 m WS
P151
A B C
KF
AF
K 261
K 262
A 271
A 272
K 161
K 162
A 171
150 m³/h Stufe
CO₂-R
P279
P173
A-110
KF
HBF
A 172 A B/C
MB 200 A 18 C
Single train
Erlassungsanlage
K-M 107
CONDENSATE
F Filter
DF Doppelschichtfilter
AF Anionenfilter
KF Kationenfilter
HBF Mischbettfilter
GR Grobrechen
FR Feinrechen
SRB Siebbandrechen
HDP Hochdruckpumpen
NDP Niederdruckpumpen
FILTER
TWO-STAGE FI-
ANION FILTER
CATION FILTER
COMBINED ANION
KATION FILTER
COARSE RAKE
FINE RAK
MACHINE
PUMP
LOW


4 HDP
GZ
FR
SIR
HDP
3,4 7500 m³/h, 53,4 m WS
2,4 5800 m³/h, 61,9 m WS
Bau 146
NDP
1 7500 m³/h, 26,4 m WS
2,3 6000 m³/h, 26,4 m WS
3 NDP
12 F
12 F
max. 1500 m³/h
1-6 UMBAG
7-12 BAHAG
WASSERMU
Süd 2800 m³ (50 x 12 x 4,5 m)
Nord 1670 m³ (2 x 2,50 x 4,5 m + 2 x 12 x 4,5)
2 Becken BASIN
1,2 2000/35
3,4 1500/35
5,6 4000/35
Bau 107
Flw. ne
1400
Becken BASIN
Becken
Bau 110
P 141
700 m³/h
16 m WS
FLOCKULATOR 100
KSU
KSU 460 m³/h
200 ø 17 m

Einlauf KSU-R		Brunnen (mit Schmelz- bzw. Regenanteil)		
		27.1. 1969	9. 11. 1970 Einlauf Sandfang	9. 6. 1969
Gesamthärte	Total hardness	12,9° dH	11,0° dH	8,6° dH
Karbonathärte	Carbonate hardness	10,4° dH	9,2° dH	7,1° dH
bleibende Härte (Nicht-Karbonathärte)	not-carbonate hardness	2,5° dH	1,8° dH	1,5° dH
MgO	(Mg^{++})	28,6 mg/l (17,2)	24,8 (15,0	19,4 mg/l (11,7)
CaO	(Ca^{++})	89,7 mg/l (64,1)	75,7 (54,1)	58,3 mg/l (42,0)
Glührückstand	• 105°C	291 mg/l	239,9	214 mg/l
Glührückstand	× 650°C	182 mg/l	146,5	122 mg/l
$KMnO_4$-Zahl	$KMnO_4$-Number	25 mg/l	21,0	19 mg/l
Gesamt-Fe	Total-Fe	0,22 mg/l	0,14	0,31 mg/l
SiO_2		3,2 mg/l	4,0	3,9 mg/l
CO_3^{--}		0	0	0
HCO_3^-		226 mg/l	201,3	156 mg/l
NO_2^-		0,06 mg/l	0,15	0,05 mg/l
NO_3^-		9,0 mg/l	12,0	14 mg/l
Cl^-		17 mg/l	11,9	9 mg/l
SO_4^{--}		38 mg/l	30,3	29 mg/l
PO_4^{---}		0,46 mg/l	0,24	0,19 mg/l
NH_4^+		0,6 mg/l	0,19	0,12 mg/l
Na^+		10,5 mg/l	7,5	6,6 mg/l
K^+		3,0 mg/l	2,4	4,0 mg/l
Leitfähigkeit	conductivity	371 × 10^{-6} S/cm	358 · 10^{-6}	263 × 10^{-6} S/cm (Siemen)
freie CO_2	CO_2 free		1,8	2,0 mg/l
Sauerstoff	oxygen		8,5	6,7 mg/l
Schwebstoffe	suspended particles		16,0 mg/l	

× residue on ignition • solid residue from evaporation dH = german hardness

	9. 11. 1970	16. 2. 1971
...rbonathärte	4,7° dH	5,1
...konathärte	1,5° dH	1,3
...mde Härte (Carbonathärte)	3,2° dH	3,8
...O (Mg^{++})	17,9 mg/l (10,5)	22,6 (13,6)
...O (Ca^{++})	22,4 mg/l (16,0)	19,3 (13,8)
...ampf...ückstand 105°C	147,5 mg/l	209,1
...Glührückstand 650°C	84,2 mg/l	101,4
...n O_4 - Zahl	5,0 mg/l	6,5
...amt - Fe	0,07 mg/l	0,06
SiO_2	2,1 mg/l	3,5
NO_3^{--}	7,2 mg/l	10,5
HCO_3^-	18,9 mg/l	5,7
NO_2^-	0,01 mg/l	0,009
NO_3^-	12,0 mg/l	15,0
Cl^-	14,4 mg/l	37,5
SO_4^{--}	32,6 mg/l	36,5
PO_4^{---}	0	0,03
NH_4^+	0,02 mg/l	0,06
Na^+	7,0 mg/l	10,9
K^+	2,4 mg/l	4,4
...fähigkeit	207 · 10^{-6} S/cm	218 · 10^{-6} S/cm
freie CO_2	n. n.	n. n.
...auerstoff	7,2 mg/l	5,3
...chwefelwasserstoff	0	0

An der Anlagengrenze steht gereinigtes Donauwasser mit folgender Beschaffenheit zur Verfügung:

pH	8,0		
Leitfähigkeit (conductivity)	263.10 $^{-6}$	S/cm	
freie CO_2	2,0	mg/l	
(free) O_2	6,7	mg/l	
Alkalität (m)	2.55	mval/l	
Härte (hardness)	8.6°	d. H.	
Karbonathärte	7.1°	d. H.	
bleibende Härte	1.5°	d. H.	
MgO	19.4	mg/l	
CaO	58.8	mg/l	
Abdampfrückstand bei 105° C	214	mg/l	(Solid residue from evaporation)
Glührückstand bei 650° C	122	mg/l	(Residue on ignition)
$KMnO_4$	19	mg/l	(max. 30)
Fe	0.31	mg/l	
SiO_2	3.9	mg/l	
HCO_3	156	mg/l	
NO_2	0.08	mg/l	
NO_3	14	mg/l	
Cl	9	mg/l	
SO_4	29	mg/l	
P_2O_5	0.19	mg/l	
NH_4	0.12	mg/l	
Na	6.6	mg/l	
K	4.0	mg/l	
Schwebestoffe max. (Suspended solids)	12	mg/l	(kurzfristig max. 200 mg/l)
durchschnittlich (average)	3 - 4	mg/l	

MUSTER
letztgültige Ausg.
bei IKA - NB

Fouling Factor (water side) — by inlet temp. of cooling water side
bei Rohrwandtemperaturen auf der Kühlwasserseite von

wasserseitig

$\leq 50^{\circ}$ C = 2×10^{-4} $\frac{m^2\ h\ ^{\circ}C}{kcal}$

$> 50^{\circ}$ C = 4×10^{-4} $\frac{m^2\ h\ ^{\circ}C}{kcal}$

Temp: 1°C in winter
20°C in summer

1974 12 14

E BEMERKUNGEN

Temp rise of return water 10°C.

LATT	CHEMIE LINZ AG	19 DAT GEZ GEP	IND 1 IND 2 IND 3	KÜHLWASSER - ANALYSE WERK - LINZ I	PROJ NR / BLATT VON BL
2/70					

ATG/Mi/K

1980 04 17

HISTORY OF N_p - PRODUKTION (ATG)

N_p.... parts of N in NH_3 (14 Mol N + 3 Mol H = 17 Mol NH_3)

Spring 1940: Beginn of raising the terrain about 2 - 4 m.

Antumn 1942: Starting of production on basic KOG.
(1 unit for desulphuration, 3 units for gas dividing and 3 for CO-conversion).

1944: Output 55 000 t Np/a

1944/45: ~ 800 bombs from allied airforces exploded in CL-area and plants.

May 45 -

July 46: No production as neither KOG nor energy were available.

1948: Output from 1944 was reached again.

Production increase

1965: to 237.000 t N_p/a or 718 t/d max.
(3 units for desulphuration, 6 for gas dividing and 7 for CO-conversion)

1966: Start up Naphtha-Steam-Reforming plant.

Increase

1974: to about 320 000 t N_p/a.

1979 ~ 520 000 t Np/a

1980 ca. 420 000 t Np/a

Naphtha - Steam - Reforming - Plant (ICI-Process)

Generals:

Engineered by Humphreys & Glasgow, London, 1964 - 1966; erected by ourselves. Laying out: 300 t Np/d (365 t NH_3/d) at a pressure of 28 (max. 31 bar). Beyond of ICI licence (our risk) we increased the working pressure (inlet prim. reformer) to 38 bar and the daily output to 420 t Np (510 t/d NH_3). We had bought machines. apparatuses and pipes qualified for the heigher pressure.

Feedstock:

1966 (start up) - 1976 Naphtha (strait run benzines)
since 1976 Natural-gas.

Maintenance:

		hours	material costs (Mio S)
1974		21 000	1,3
75	general overhaul	56 000	7,4
76		24 000	1,6
77	general overhaul	46 000	4,2
78		16 000	1,6
79		21 000	2,3
80	(3 months)	3 000	0,1

On stream days:

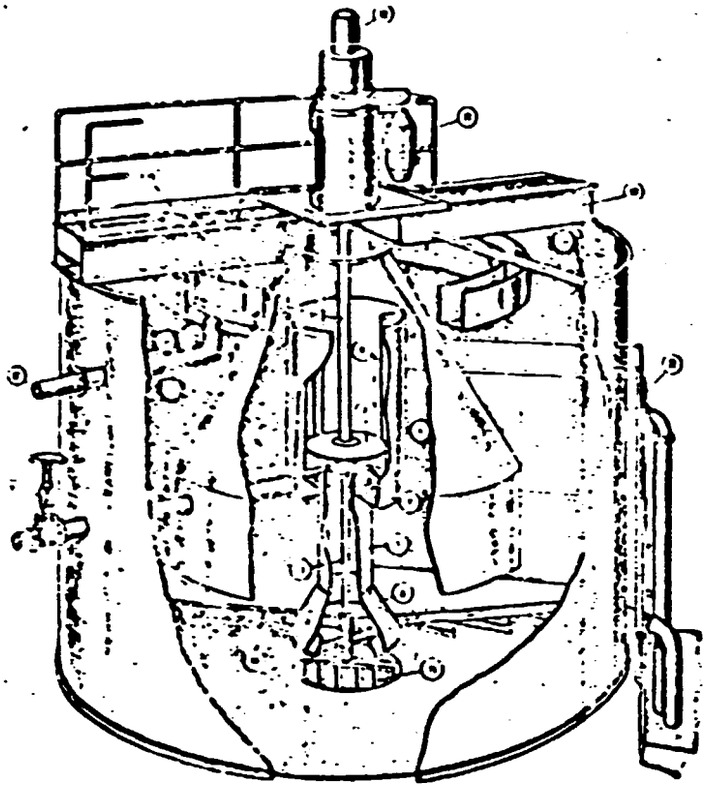
1974		363
75	general overhaul	324
76		366
77	general overhaul	325
78	intended 3 days-shut down during single-train-shut down for welding piping - connectiens between both plants.	362
79		365
80		till now

KSU - Reactor (Flocculator)

The "Contact-Mud-Circulation-Reactor" is especially used for conditioning of surface water which must be cleared of suspended matter, colouring substances, organic dirts and carbon. Furthermore good results are attained in other fields of water treatment, especially at deironing, demanganition, deacidifying, deoiling, sterilizing (degerminating), removing of disagreeable odour- or flavour substances, but also algas and float slime. In the water treating process many of these effects are to be attained simultanously.

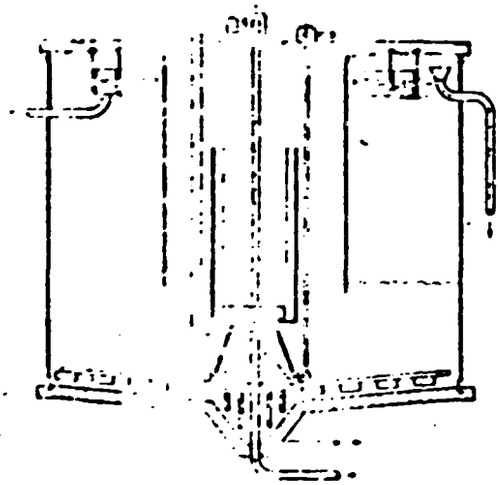
1. Inlet
2. Inlet control valve
3. Cone
4. Top ascending pipe
5. Lower ascending pipe
6. Lengthening pipe
7. Mixer
8. Rotation crusher
9. Untreated water distributer
10. Mainshaft of mixer
11. Variable speed motor (for the mixer)
12. Desludger motor
13. Shaft of desludger
14. Desludger
15. Sludge bottom with mixer
16. Clear water collecting channel
17. Outlet of clear water
18. Catwalk and rail
19. Bridge
20. Overflow
21. Sampling pipes

KONSTRUKTION

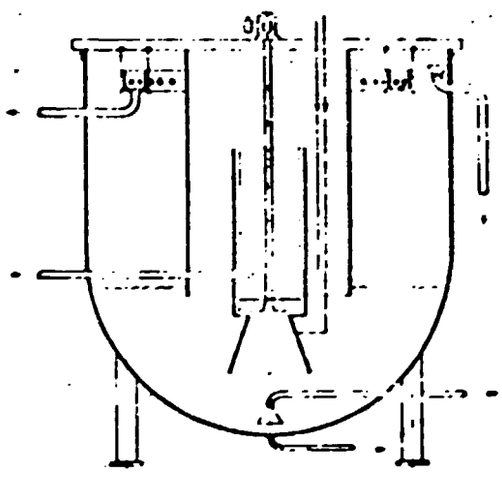


1. Zulauf
2. Zulaufregelventil
3. Konus
4. Oberes Steigrohr
5. Unteres Steigrohr
6. Steigrohrverlängerung
7. Rührwerk
8. Wirbelbrecher
9. Rohwasserverteilung
10. Rührwerk-Antriebswelle
11. Regelbarer Antriebsmotor für Rührwerk
12. Schlammräumerantrieb
13. Schlammräumer-Antriebswelle
14. Schlammräumer
15. Schlammsumpf mit Rührwerk
16. Reinwassersammelrinne
17. Reinwasserablauf
18. Steg und Geländer
19. Lagerbrücke
20. Überlauf
21. Probeentnahmestellen

BAUWEISEN



Stahlbehälter mit Betonsohle



Ganzstahlbehälter ohne Schlammräumer

Die obigen Bauweisen können beliebig kombiniert werden

General, technical data

Capacity:	5 - 3 000 m^3/h (per unit)
Turn-around time: (dwell time)	about 60 - 90 minutes
Internal circulation:	3 - 5 x Quantity of flow (Capacity)
Saving of chemicals:	30 - 40% compared to conventional plants
Speed of climb-up:	ca. 3 - 5 m/h
Transparence in cleaned water:	often 1,5 - 2,0 m
Turbidity content in discharged water:	10 mg/l, often 3 - 5 mg/l
Rate of blow down:	0,5 - 1,0% of capacity
Mud content:	15 - 25 g solid matter/l (97,5 - 98,5% water)

Function

First the untreated water flows into the cylindric middle-part and is there mixed with recycled deposite products and chemicals. The rising stream is produced by a speed regulated mixer which works like a circulation pump. This mixer makes a good mixture of all components: raw water, chemicals and chemically activ mud. By help of the contact effect of mud the formation of flakes begins immediately, increasing then quickly. After having passed the mixing zone water comes into the reaction zone and changes its streaming direction. In this zone all chemical reactions happen whereby the flakes grow and grow.

Then a part of the water comes into the ascending pipe, while the other part streams to the outern parts of the reactor. On the bottom edge of the lower cylindric part of the big cone a sharp seperating zone is formed between mud and clear water. Mud particles sink to the bottom; clear water rises to the surface. In the outern area of the big cone the climbing speed goes slower and therefore even small mud-particles cannot rise. The clear, conditioned water flows into a top collecting channel (grouve). By a slowly turning desludger the sunken mud is transported into the slim pit and then further thickened. An automatic valve removes the mud from the reactor in intervals.

Operation

The characteristic feature of the KSU-reactor is the internal circulation; a quantity of 3 - 5 times of the capacity flow is circulated in the mixing and flocculent zone. In this cycle a lot of activ mud is carried along, so that each particle of raw water often touches mud and chemicals. The particles of slim work as crystal centers on which products of precipitation settle down directly. This principle of so called "contact mud circulation" is the real reason for the surprisingly good conditioning effect. Good working of the reactor can be seen on the sharp separating zone between muddy water and rising clear water, further on the quick sinking process of old dereacted mud.

Total demineralization / Fundamental principles

Since long time it is know, that salts dissolved in water dissociate more or less into their components, that means into ions. Common salt, (kitchen salt) for example, dissociates to the positive sodium ion and the negative chlorine ion. By this dissociation water is electrically conductive and so it is possible to separate cations and anions by direct current. Nearly all salts dissolved in water dissociate so in cations and anions and the most important of them can be put in order as to be seen in the following scheme:

cations	anions		
Ca	$(HCO_3)_2$	K	
Mg	$(HCO_3)_2$		
Ca	SO_4	N	H
Mg	SO_4		
Ca	Cl_2		
Mg	Cl_2		
Na	Cl	neutral salts	
Na_2	SO_4		
Na_2	SiO_3		
K	= carbonate hardness		
N	= not-carbonate hardness		
K + N = H	= total hardness		

Not all ions are equally good absorbed or delivered by ion exchangers. A very good exchanging is given between cations and hydrogen ions and between anions and hydroxyl ions. Polyvalent ions of heavy metals, like iron and maganese are first taken up by cations, followed by alkaline earths, like calcium and magnesium, and at last potassium and sodium. A cation exchanger, which is loaded with these ions is regenerated by acid. In this process the cations are pushed away by the hydrogen ion of the acid. According to the law of mass action (Guldberg and Waage's law) a surplus of acid is necessary (opposite to the theoretical quantity) for finishing the regeneration. The same is current for the regeneration of anion exchangers by sodium hydroxide solution. If ion exchange substance is exhausted, the ion most difficult to be exchanged will break through first. It is sodium at the cation exchanger and it is silicic acid at the anion exchanger.

The ions which are able to be exchanged are not only on the surface of the grains of the exchange resin but also inside (interior). That means that exchanging reactions need a certain minimum time, to obtain relations between quantity of water, speed of filter process and quantity of exchange resin.

Variations are possible, like strongly acidic and slightly acidic cation exchanger, or strongly basic and slightly basic anion exchanger. Slightly acidic cation exchangers can be regenerated without a surplus of acid and slightly basic anion exchangers without a surplus of sodium hydroxide (caustic soda). In a combined employment of "slight"- and "strong"-exchangers it is possible to further use the surplus of chemicals which is absolutely necessary for the "strong"-exchangers for the regenerations of the "slight"-exchangers. By this a lot of chemicals can be saved. So it is more economic.

The combination of a contact mud circulation reactor with sand filters and a total desalization (demineralizatio) enlarges the economical possibilities of application of total demineralization plants, especially of plants with large hourly capacities.

Total demineralization / Process

Such a plant consists of cation and anion exchangers which must be regenerated when the substance (resin) is exhausted. The regeneration process lasts 4 - 6 hours. In this time the plant is working with another row. So it is necessary to have at least two rows of apparates. Further it is a great advantage to have clear water reservoirs (vessels) at the end of the plant for short time requirements of 3 - 4 hours, e.g. for small repairs or short troubles.

Mixed bed filters are situated only in the last stage; they are considered to be safety devices. The water treatment should be finished before mixed bed filters. They have only the function to catch, or to kill irregularities or natural "slippage". By this, working safety (reliability) of the plant is increased, and for pre-inserted filter groups costs in dimensioning of all apparatus (filters) and operating expenses can be saved, because these apparatus can be fully loaded without risk.

Druckvergasung

Werkstoffblatt.

Apparate (-teile)	Werkstoff.
Spaltrohre v. Primärref. Furnace Tube	G-X 40 CrNiSi 25 20, W.Nr. 4848 HK40, ASTM A-297 ; 25Cr/20Ni
Austritts-Sammler Outlet Header	Gußteile: 18/37 CrNi - Leg. Schmiedet.: Incoloy 800 Centrifugal and Static Castings: 37Ni/18Cr Wrought Fittings: Incoloy Alloy 800
Pigtails Outlet Pigtails	Incoloy 800, W.Nr. 4876 Incoloy Alloy 800
V103 - Sekundär Reformer V103 - Secondary Reformer	Mantel: 19 Mn 5 - W.Nr. 0845 Flansche: 41 KT (W.Nr. 0425 $\frac{2}{3}$ H$\overline{\text{II}}$) Schrauben: 24 CrMoV 55 - W.Nr. 7733 Shell: ASM: A 105 GII (P1), A 242 Gr. B Flange: ASTM: A 515-60 Bolts: ASTM: A 320 Grade L7, A 193 Gr B16
211 - Rauchrohrabhitzekessel HP. Boiler	Mantel: 17 Mn 4 - W.Nr. 0844 Rohre: 13 Cr Mo 44 - W.Nr. 7335 Flanschen: 13 Cr Mo 44 Shell: A 105 Gr. I (P1) Tubes: A 335 Gr. P11 Flange: A 387 Gr B P4
V104 - Primär CO-Konverter V104 - Primary CO-Converter	Mantel: 16 Mo 5 Flansche: 15 Mo 3 W.Nr. 5415 Shell: ≈ A 204 Gr. A, ASTM: A 335 Gr. P Flange: A 204 Gr A
H 101 - Abhitzekessel H 101 - Make Gas I.P. Boiler	Mantel: St. 41 KT = H$\overline{\text{II}}$ - W.Nr. 0425 Rohre: St 45.8 $\overline{\text{II}}$ W.Nr 0405 Shell: ASTM - A 515-60 Tubes ASTM - A 106 Gr. B

Druckvergasung — Werkstoffblatt

Apparate	Werkstoff.
V-105 Schwefelauffangbehälter V-105 Sulphur Catch Vessel	Mantel: 19 Mn 5 - W.Nr. 0845 Flansche: C22N - Schrauben: 24CrMo5 - Shell ASTM: A 212 Gr. B, A 105 Gr II P1 Flange ASTM: A 105 Gr. I Bolts ASTM: A 194 Gr 4
V-106 Tieftemperaturkonverter V-106 Secondary CO Converter	Mantel: 19 Mn 5 - W. Nr. 0845 Flansche: C22N - Schrauben: 24CrMo5 - WNr. 7258 Shell: ASTM A 212 Gr. B, A 105 Gr II P1 Flange: ASTM A 105 - II Bolts: ASTM A 194 Gr 4
H-102 Abhitzekessel III H-102 Make Gas I.P. Boiler III	Mantel: St 41 KT = H II - W.Nr. 0425 Rohre: St 45.8/III W.Nr. 0405 Shell: ASTM: A515 Gr. 60 Tubes: ASTM: A210 Gr. A-1
H-103 Speisewasservorwärmer H-103 Boiler Feedwater	Mantel: St 41 KT = H II - W.Nr. 0425 Rohre: X10CrNiMoNb 1810, W.Nr. 4580 Verkleidung: -"- W.Nr 4580 Shell: ASTM: A515 Gr. 60 Tubes: ISO: R683 T13/23a ≈ ASTM A 240 Gr. TP 316 (P8)
V-112, V113, V114, V115 Gasabscheider V-112, V113, V114, V115 Make Gas K.O. Drum	Mantel: 17 Mn 4, W.Nr. 0844 Verkleidung: W.Nr. 4580 ≈ X10CrNiMoNb 18 10 Shell: ASTM: A 105 Gr. I P1 Demister: ≈ ASTM: A240 Gr TP 316 (P8)

Druckvergasung

Werkstoffblatt

Apparate id Kennzeichn.		Werkstoff
Dampfüberhitzer Dampfüberhitzer	$H_{2/1}$ F 101 $H_{2/3}$ F 101	X12 CrNiTi 18 9, W.Nr. 4878 10 CrMo 910, W.Nr. 7380
	$H_{2/1}$ F 101 $H_{2/3}$ F 101	Austenitic Steel Cr-Ni ISO: 17/4 N634 (H32) ASTM: A199 Gr T22 (P5), A335-P22
Dampfüberhitzer Dampf-Erdgas Überh.	$H_{2/4}$ F 101 $H_{2/2}$ F 101	10 CrMo 910, W.Nr. 7380 / 800 10CrMo910, W.Nr. 7380 und Incoloy / W.Nr. 4876
	$H_{2/4}$ F 101 $H_{2/2}$ F 101	ASTM: A199 Gr. T22 (P5), A335-P22 Austenitic Steel Cr-Ni, ISO: 17/4 N634 Incoloy 800
Prozessluftvorwärmer Erdgasüberhitzer	H_1 F 101 $H_{2/2}$ F 101	10 CrMo 910, W.Nr. 7380 und X12 CrNiTi 18 9, W.Nr. 4878 10 Cr Mo 910, W.Nr. 7380
	H_1 F 101 $H_{2/2}$ F 101	ASTM: A199 Gr T22 (P5), A335-P22, Austenitic Cr-N ASTM —"— A335-P22

Kesselspeisewasseraufbereitungsanlage - Werkstoffblatt

Boiler feed water treatment - List of materials

Anlageteile Parts of plant	Werkstoffe Materials
Kiesfilter mit Armatur. und Rohrltg. Sand filters with fittings and piping	C-Stahl, RSt 37.2 mit Innenanstrich with internal painting Rohre: St 35. Armat. Graugus GG 20 Carbon Steel - ASTM: A283-C Tubes: A 53-A, Valves: Grey Iron, A 126 - classe B
Ionenaustauscher mit Rohrltg. und Armat. Ion-exchangers with fittings and piping	C-Stahl RSt 37.2, innen gummiert, oder Aust.-Stahl. internal rubber coated or Vessels: Carbon Steel A 283-C stainless steel Cr-Ni Steel A 264 Grade 6, 347 clad. Tube: A53-A austenitic CrNi Stee Valves: A 126 - classe B -or- CrNi Cast Iron
Pumpen im Bereich d. Ionenaust. Pumps in the acrea of ion-exchangers	GG 25 innen gummiert, oder Austenitischer St. W.Nr. 4580 internal rubber coated or stainless steel A 126 class B AISI 316 CB
H_2SO_4 (76%) Dosierpumpen samt Ltg. und Armat. H_2SO_4 (76%) - dosing pumps with f. and pipes:	PVC (mit H_2SO_4 benetzte Teile) Teflon PVC (Teflon)
NaOH (50%) Dosierpumpen + Leitungen und Armaturen NaOH (50%) - dosing pumps with f. and p.	CrNi Stahl W.Nr. 4571 stainless steel AISI 316 Ti
$FeCl_3$ - Dosierpumpe $FeCl_3$ (ferric chloride) - - dosing pump	PVC (Teile mit $FeCl_3$ benetzt) PVC
KSK - Reaktor	C - Stahl Baustahl mit Korrosionsanstrich Carbon Steel normal steel with painting

Durchsicht des Triebwerkes bei der 2. u. 3. Stufe-Kompressor Ost

Reparaturvorgang	Steps:
1. Führungsringmessung bei allen 4 Zylindern	Measurement of guide rings at all of the 4 cylinders.
2. Kühlräume bei allen 4 Zylindern reinigen.	Cleaning of cooling rooms of all cylinders.
3. Prüfen der Kolbenstangenlage mit Rahmenwasserwaage. (im oberen und unterem Totpunkt) Der Kreuzkopf muß an der Lauffläche angedrückt werden.	T. Inspect the position of piston rod with frame level (at upper and bottom dead centre) The crosshead must be pressed on the running surface.
4. Kolben mit Kolbenstange ausbauen und bei THW prüfen bzw. egalisieren lassen.	Remove piston and piston rod. To inspect or to flush (to level) the surface in the mainshop.
5. Laufbüchse ausbauen, durch TMP prüfen und wieder einbauen. Weiters Kreuzweise im unteren und oberen Totpunkt vermessen, sowie mit Rahmenwasserwaage überprüfen. Die Überprüfung der Laufbüchse muß bei eingebauten Ventilen durchgeführt werden.	Remove bush, inspecting by TMP and build in again. Measurement over cross at upper and bottom dead centre. Inspection with frame level. Inspection must be done <u>with</u> valves fitted.
6. Kreuzkopfspiele messen.	Measurement of clearance of crosshead.
7. Kreuzkopfbolzen ausbauen. Zustand der Passung überprüfen und festhalten (~~einölen~~)	Remove bolt of crosshead. Inspection of state of fit
8. Kreuzkopf ausbauen und bei TF prüfen und ev. egalisieren lassen. (Stangenloch und Kreuzkopfbund)	Remove crosshead and inspect in mainshop. (T. flush the surface)
9. Gegengewicht ausbauen.	Remove balancing weight
10. Pleuelstange ausbauen.	Remove side rod
11. Messung der Atmung bei 0° - 90° - 180° - 270° - Kurbelstellung.	Measurement of breathing (swelling) of crankshaft
12. Feststellung des Pleuellagerspieles (Messung des Kurbelzapfendurchmessers und des Ø von Pleuellagerbohrung)	Measurement of clearance of connecting rod bearing (big-end bearing) Measurement of 2 Ø (crank pin, [and] crank eye)
13. Bei ev. Korr. des Pleuellagerspieles müssen die Pleuellagerschrauben gemäß angegebener Dehnung angezogen werden.	If modification of clearance is necessary, bolts must be fitted according to settled (defined) extension

14. Bei Pleuellagerzusammenbau achten, daß beide Lagerschalen im Gehäuse festsitzen.

Both bearing bushes (pillows) must be fix in casing!

15. Pukt 3 - 13 gilt für beide Stufen.

Points 3 - 13 is equally for both stages.

16. Nach der Messung der Atmung bei beiden Stufen Hauptlager 2, 3, 4, u. 5 ausbauen.

After measuring of swelling of both stages, remove the main bearings Nr. 2, 3, 4 u. 5

17. Ausbau der Hauptlager
   a) Zuerst Messung des Lagerspieles
   b) Schraubenlänge im angezogenen Zustand festhalten
   c) Schraubenlänge im entspannten Zustand festhalten.
   d) Lagerschalen ausbauen, Die Kurbelwelle muß zum Zwecke um ca. 1/2-Lagerspiel hydraulisch angehoben werden.
   e) Lagerschalen durch TMP prüfen lassen.
   f) Wellenlagerzapfen durch TMP prüfen lassen.

Removing main bearing
a) Measurement of clearence
b) Notice lenght of bolts in fixed state.
c.) Notice lenght of bolts in loosen (unscrew) state
d.) Remove pillows. The crankshaft must be liftet by hydraulic tool the half of the clearance.
e.) Inspecting of pillows by TMP
f.) Inspecting of bearing necks (journals) by TMP.

18. Hauptlager einbauen.

Replace main bearings

19. Atmung messen - Kontrolle (siehe Pkt. 14) beide Stufen

At both stages: Like Point 11)

20. Ausmessen der Kreuzkopfbahnen (Durchmesser und Parallelität)-beider Stufen

Measurement of guideway of crosshead. (⌀ and //) of both stages

21. Ausschleifen der beiden Stufen und ev. Zylinder-Korrektur.

b - Measurement of cylinder

22. Pleuelstange einbauen.

Replace side rod.

23. Kreuzkopf einpassen und einbauen.

Replace crosshead

24. Stopfbüchsenpackungen, Ölabstreifung und Kolben (ohne Bespannung) einbauen. Messung der Kolbenlage im angedrückten Zustand.
Der Kolben soll an der Ostseite (Laufseite des Kreuzkopfes) mindestens einen Abstand 1,7 - 1,8 mm bei der 2. Stufe und 1,4 - 1,5 mm bei der 3. Stufe von der Laufbüchse

Replace air packing, oil packing and piston (without rings!)
Measurement of state of piston (Clearance between piston and bush) Distance on the side on which the crosshead slides

haben. Das heißt, im bespannten Zustand darf keine Zwangslage des Kolbens entstehen.

25. Kolbenstangenlage mit Rahmenwasserwaage prüfen.

Testing the state of piston rod with frame level.

26. Fertig - Zusammenbau Schadräume messen.

Finish assambling, measurement of dead space.

27. Luftfilter, Ölfilter, Ölwanne, Rifox, Impulsleitungen reinigen. Ölfüllung Dichtheitsprobe der Luftkühler.

Cleaning of: Air filter, oil filter oil tub (tank), steam traps. New oil filling. Tightness tests of air coolers

28. Probelauf

Test run.

29. Prüfung durch TMP

Inspections by TMP

a) Gewindekontrolle — Screws and threads
b) Kreuzkopf — Crosshead
c) Lagerschalen — Pillows
d) Lagerzapfen — Bearing necks (journa
e) Dehnschrauben (Hauptlager, Pleuellager, Gegengewichte, Stangenkupplung) — All antifatigue shafts of screw
f) Zylinderlaufbüchse (Bund) — Shoulder of bushes
g) Zylinderdeckel (Rippen) — Ribs of cylinder covers (tops
h) Zylinder-Innenrippenverstärkungen. — Ribs of cylinders
i) Zylindergehäusebund (Verbindung zwischen Zylinder und Maschinengehäuse). — Shoulder of cylinders (Connection between cylinder and casing)

TMD

PAPER 4

BLANKING-OFF REFORMER TUBES DURING PLANT OPERATION

B. ESTRUCH

1. Introduction

When a reformer tube bursts during service the loss of gas through the leak is not necessarily intolerable, but the leaking gas ignites inside the furnace and causes overheating of the surroundings. To prevent damage to the refractory and to the neighbouring tubes, it is necessary to isolate the failed tube.

To achieve this, either the design must make provision for shutting off any individual tube or, if simple welded up connections are used, the whole unit must be shut down and cooled so that the failed tube can be cut out and replaced, or the connections plugged by welding.

Because the outlet pigtails usually operate in the region 700-800°C, and no valves are known that could be fitted in each pigtail, and because at any rate, the expense and complication of fitting them in the design would be considerable, an all welded design is normally adopted. Initially, when an overheated tube leaked, the furnace had to be taken off line losing some 36 hours production. This represented a serious loss of output. Apart from that, in reformer plants built for the production of town gas, the manufacturing authority is under legal compulsion to maintain a minimum gas pressure and it could hardly afford to shut down a furnace even for only 30 hours, should a tube fail during a period of peak demand. Consideration was, therefore, given to methods of blanking-off leaking tubes, which would not necessitate shutting the plant down.

2. Background

It has been standard practice for many years to squeeze mild steel pipes on gas and water service when it had become necessary to isolate a line, and a number of devices are commercially available for this purpose. However, the application of gross plastic deformation to pressure equipment containing hot inflammable gases had not been considered. The commercially available apparatus for low temperature service are hydraulically operated, which is an advantage, but their frame has to be dismantled and then reassembled on to the pipe to be squeezed. This would have been perhaps acceptable for inlet pigtails where the temperature is around 400°C, but the manipulation involved would not be acceptable in the proximity of the hot outlet pigtails (700-800°C). For that reason a G clamp squeezer was designed so that the unit could be placed onto the pigtail where it runs horizontally adjacent to the reformer tube (Clark and Elmes Paper 2, Fig. 2) and all that was required in the way of preparation was to remove the lagging on this section.

3. G Clamp Squeezer

Details of the squeezer are given in the drawing in Fig. 1 and the photograph of Fig. 2. It is driven by a short 6 ton hydraulic ram, manufactured by Epco Flexi-Force.

The main advantages of this design are:

(1) The G shape of the frame reduces manipulation near the pipes before squeezing to hanging the device onto a horizontal part of the pigtail.

(2) It is connected to the pump by means of a pressure hose of convenient length so that the operator is at a safe distance while the tube is being squeezed. It is relevant to mention

here that in the event of a pigtail cracking while being squeezed. Billingham experience has shown that the fire that results from a pigtail failure does not cause significant damage.

(3) Should any accident happen to the hydraulic ram, to the hose, or to the pump, the quantity of oil involved is very small (1-2 pints).

(4) After squeezing, the jaws can be fastened together by means of screws to form a permanent clamp to prevent the internal pressure opening up the squeezed pipe. The G clamp and hydraulic ram can then be removed by simply letting the jaws slide off along the guides shown in the drawing.

(5) The jaws are kept in position by means of ball catches while the clamp is being hung and while pressure is being applied.

(6) Two lateral sheet metal pieces locate the clamp jaws on the pipe, and are crushed away as the squeezing operation is in progress.

4. Laboratory Tests

Although from the above considerations it appeared that blanking-off reformer tubes by flattening the inlet and outlet pigtails could be achieved with reasonable safety, it was decided to carry out some preliminary tests on a laboratory scale.

In order to simulate plant conditions, a test rig was arranged in which a length of pipe could be electrically heated by making it an integral part of a circuit connected to a low voltage high current source. One of the ends of the tube was blanked-off and the other connected to a 275 p.s.i.g. steam line. Provision for measuring the steam pressure and for measuring and controlling the temperature during the tests was made. Samples of both Incoloy and Cr-Mo pipe were tested. The clamp itself was tested under a 7 ton load without it showing any permanent set.

4.1 Incoloy Pigtails

Two samples of extruded Incoloy DS tubing, 1.11/32 in. o.d. x 8 s.w.g. as used for the fabrication of the outlet pigtails were used for the trials. One sample was ex-stores, but was aged for 72 hours at 800°C in order to bring it into a condition nearer to that of the pipes after service. The second sample was cut from an actual pigtail which had failed due to the presence of manufacturing defects after a few months in service.

These samples were heated to 800°C before squeezing. During the first test as the jaws touched the tube, the temperature dropped quite considerably, but by insulating the ends of the pipe, the temperature drop was eventually reduced to about only 20°C.

In all, eight trials were performed. The results were completely satisfactory, except in one case, when a number of small cracks developed on the outside of the pipe, but no leak occurred. This cracking was not thought to be significant because the trial was done on a part of the pipe which had been overheated to nearly melting point during the initial attempts to adjust the temperature. Figure 3 shows the general appearance of the tube and Figure 4 a cross section through one of the flattened parts.

4.2 Cr-Mo Pigtails

The tests were done at 400°C on a length of 1% Cr-Mo steel pipe 13/16 in. o.d. x 5/32 in. wall as used for the inlet pigtails. At this temperature the tube was too strong for the squeezer and a perfect flattening could not be achieved. In order to increase the stress on the pipe, the width of the jaw faces of the clamp was reduced from $\frac{1}{2}$ in. to $\frac{1}{8}$ in., but then the ductility of the material was insufficient and the tube wall sheared. It was found possible to avoid this by carrying out the operation in two stages. In the first, a set of jaws with $\frac{1}{2}$ in. wide and slightly curved faces was used. This spread the deformation over a large area, but still left a gap between the two wall faces. A second pair of jaws with faces $\frac{1}{8}$ in. wide, and semi-circular cross section was used to close the gap. To achieve this the load had to be increased to 8.5 tons. The clamp withstood this overload well. Figures 5 and 6 show the results of the tests.

During the tests it was found that the original jaws in 18/8/Ti were too soft and yielded appreciably during operation. This was prevented by protecting the jaw faces with welded inserts of heat treated FV520 (B) steel whose yield strength is about three times higher than that of 18/8/Ti steel.

5. Plant Experience

The pigtail squeezer has been used successfully on several occasions to isolate leaking reformer tubes. Squeezing the inlet pigtails has proved to be as easy in the plant as it was in the preliminary trials.

On the other hand, with outlet pigtails trouble has been experienced on three or four occasions owing to cracks forming during the operation. It appears that the difficulties are due to a combination of the following factors:

(1) Embrittlement during service. It is known that the ductility of Incoloy DS decreases with time due to an age hardening process. The use of Incoloy 800 which is now readily available and reputed to be less prone to embrittlement during service will probably improve matters.

(2) Decrease in temperature. As soon as the flow of hot gas through the pigtail is restricted the metal temperature begins to fall and so does its ductility. The more quickly the operation is completed the less likely it is for trouble to occur. The possibility of increasing locally the temperature of the outlet pigtail prior to squeezing is also being considered.

(3) The occasional presence of score marks on the surface and stringers of inclusions inside the pipe wall which facilitate the initiation and propagation of cracks.

In spite of these occasional difficulties it has always been possible to blank-off the failed reformer tube. Even after cracks have appeared in the pigtail its flattening has been achieved at a second attempt.

The use of screwed on jaws to maintain the pigtail gas tight has proved necessary. Whenever the jaws have been removed, the leakage of gas from the reformer tube has been seen to increase gradually becoming excessive after some time. A second application of the squeezer and permanent clamping

of the pigtail has been sufficient to reduce the leakage to a negligible amount.

Conclusion

Blanking-off failed reformer tubes without having to shut the plant down, by squeezing the inlet and outlet pigtails at temperature and under pressure, has been a complete success. So far no untoward incidents have occurred and provided adequate care is taken, the isolation of the failed tube can be achieved without danger to the operating personnel or to the plant.

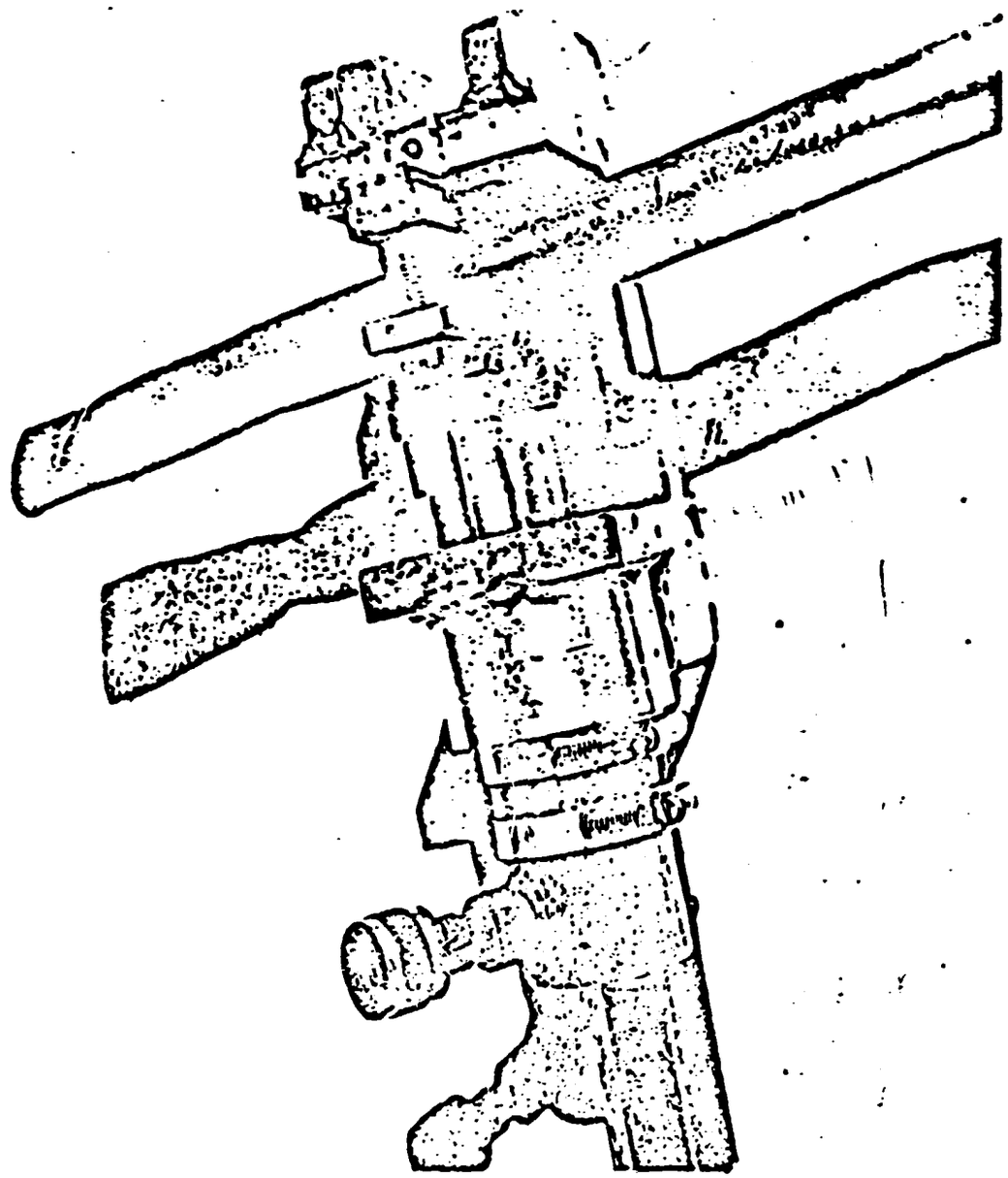


FIG. 2 C CLAMP IN OPERATION

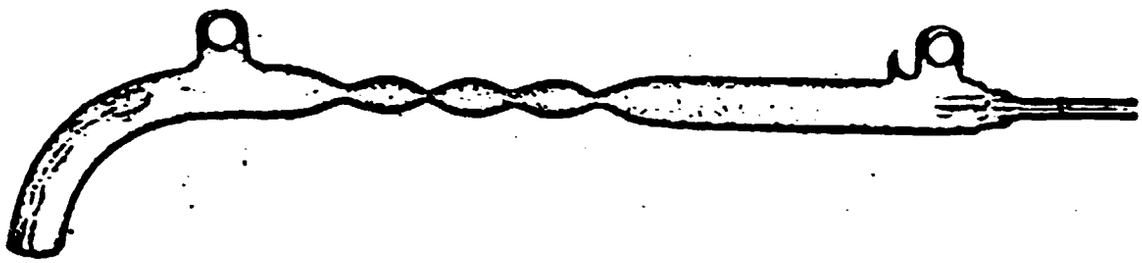


FIG. 3 OUTLET PIGTAIL PIPING (INCOLOY DS) SQUEEZED AT 800°C

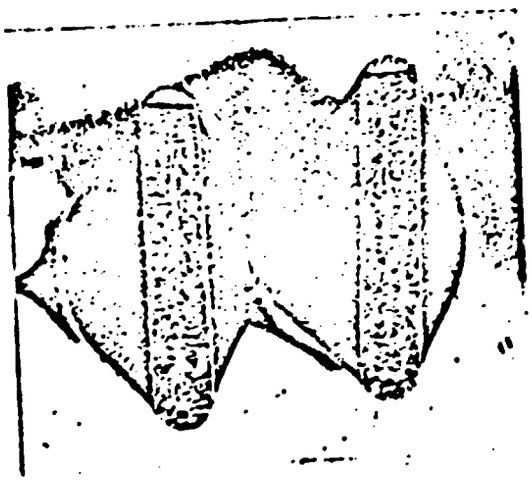


FIG. 4 CROSS SECTION THROUGH PIPE IN FIG. 3

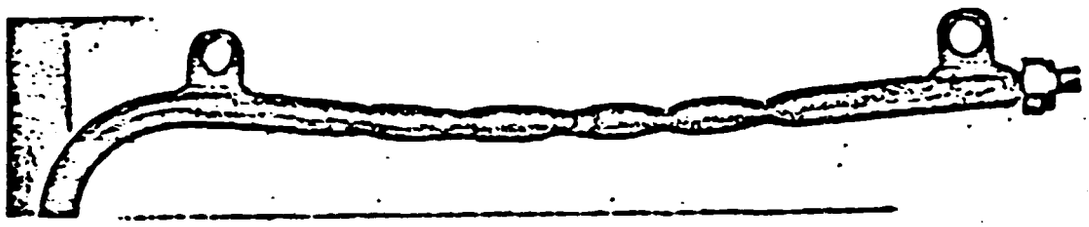


FIG. 5 INLET PIGTAIL PIPE (1% CR-MO) SQUEEZED AT 400°C

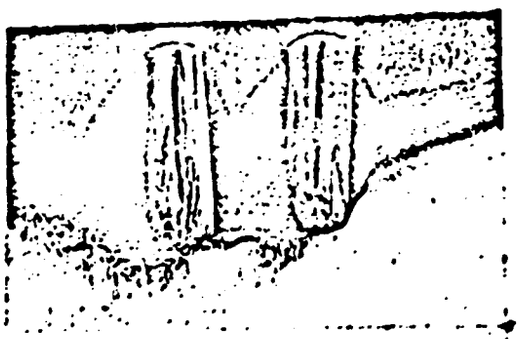


FIG. 6 CROSS SECTION OF PIPE IN FIG. 5

Adsorption-Safety-Loop in Linde's air separation plant

From main condenser liquid oxygen comes to a pump which delivers it alternatively to one of two adsorption vessels filled with gel. Then liquid oxygen flows back to the main condenser. By this the liquid O_2 is permanent in circulation through an adsorption apparatus. It holds back (adsorbs) 98% of acethylene and propylene (propene). All hydrocarbons not adsorbed, like ethene, propane and so on somewhat enrich in the fluid.

By permanent taking out of the adsorption safety loop 1% of O_2-production and by evaporation of this rate the remaining hydrocarbons are removed from the separation column (main condenser) for the most part.

The adsorption vessel has a service life of 8 days. After this time filling must be regenerated and the circulation happens through the other vessel. The content of acethylene in the main condenser is limited with 0,1 ppm. Analysis are made daily. By reasons of safety hot nitrogen (with a pressure of .5 bar) is used as regeneration medium.

SOME FIGURES
OF THIS DOCUMENT
ARE TOO LARGE
FOR MICROFICHING
AND WILL NOT
BE PHOTOGRAPHED.

4. UNIDO-Workshop

Responsibility of ATN

1. Improve & ensure safety of operators & equipment;

2. Maintenance of plant to assure high productivity

3. Improvement of existing equipment & process (together with APN) toward higher productivity, lower production & maintenance costs.

4. Costcontrol of maintenance activites.

5. Liaison with other departments of Chemie Linz to coordinate interdepartmental work (main workshop, instrumentation, etc.)

6. Assist public organisations to cope with disasters. (chemical spills on roads etc.)

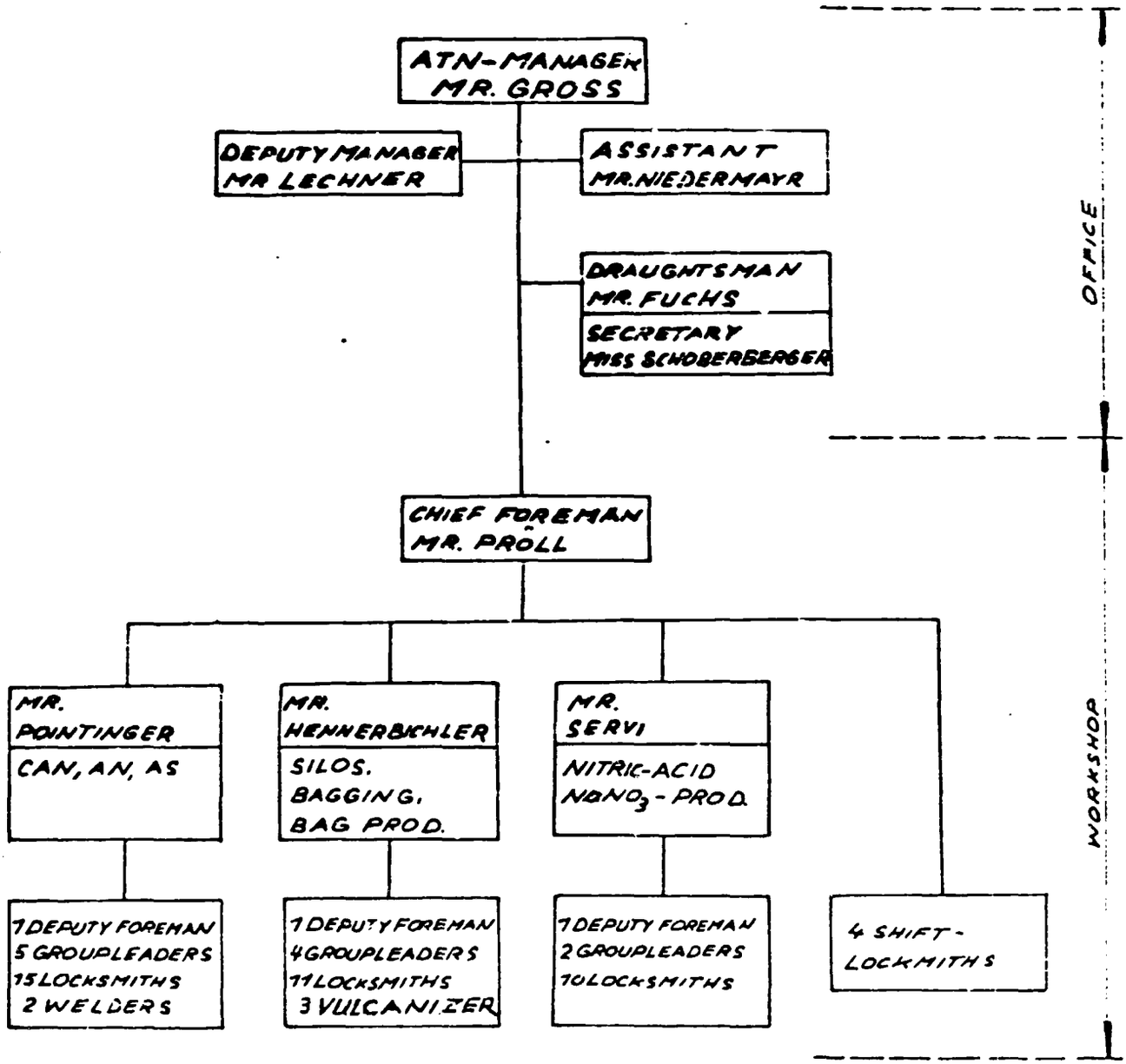
On-Call service

from friday 14,00 to monday 6,00

1 engineer or foreman
1 mechanic - (only in areas without shift-mechanics!)

ORGANISATION DEPT. ATN

A.....DIVISION A (AGRICULTURAL CHEMICALS)
T.....TECHNIC
N....NITRATE PLANTS



THE FORMEN ARE ALLOCATED TO THE CERTAIN PLANTS.
THE WORKERS - IF NECERSSARY - MAY BE SHIFTED BETWEEN
THE 3 FOREMAN-GROUPS.

Shut down of plants

Caused by limited manpower generally only one plant may be shut-down for overhaul.

p.e: 1) AC plant Enns
shut-down 23. April 1979
duration: 1 week

2) Nitric Acid plant
shut-down 2. May 1979
duration: 1 week

3) Urea plant
12. May - 23. May 1979

4) Single train: unscheduled shut-down for one day only

Manpower normally allocated to individual plants is sufficient only for normal maintenance. For shut-downs the group must be increased in size.

p.e: Nitric Acid plant shut-down

normal maintenance crew (group Servi)	13 men
plus from ATN (group Hennerbichler)	8 "
" " " (group Pointinger)	8 "
" " THW (central workshop)	20 "

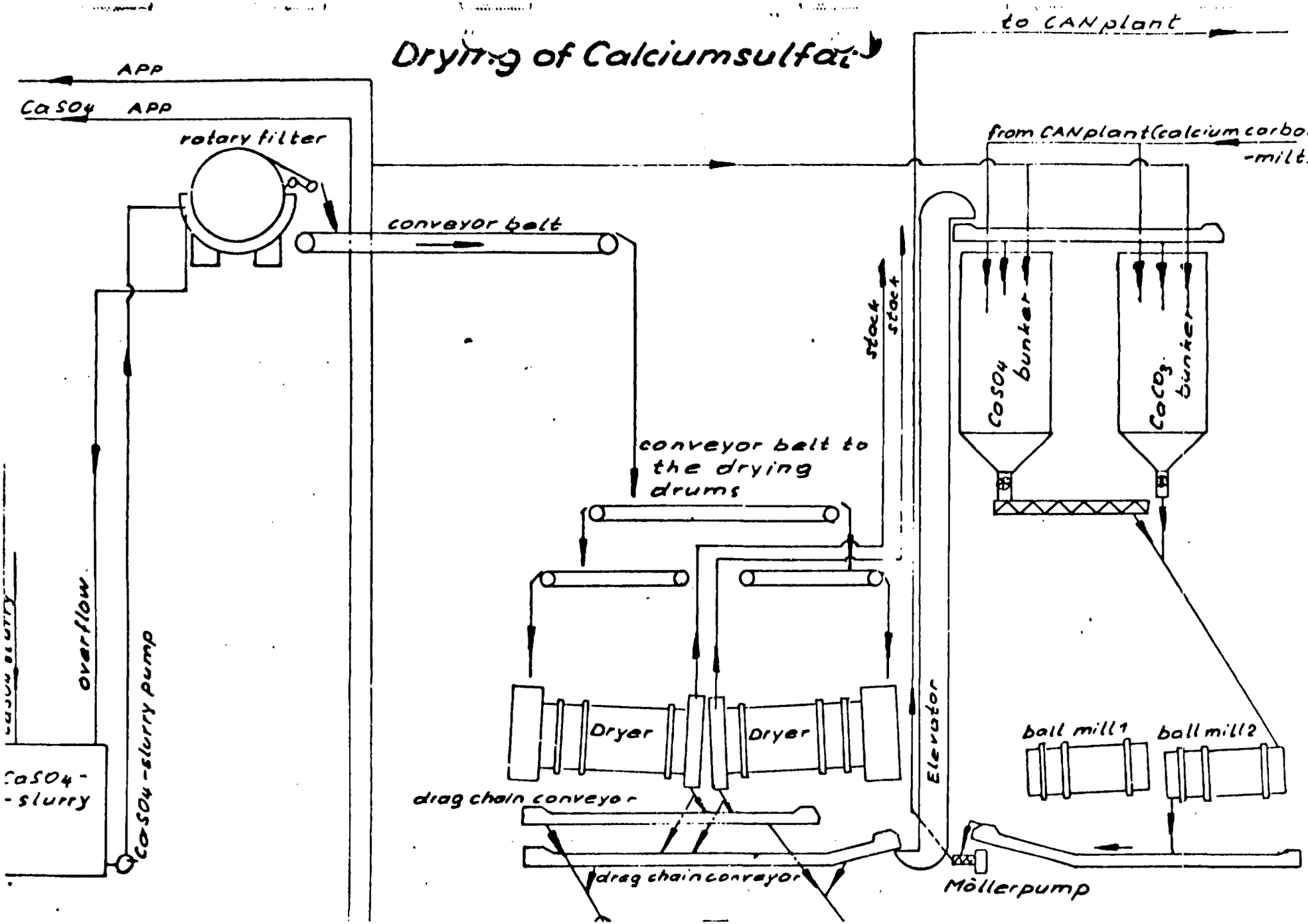
Additional hands are used to increase individual work-groups or are given complete tasks!

MATERIALS USED BY ATN

CODE		COMPOSITION						APPLICATION
mat-number	internat. code	C	Si	Mn	Cr	Mo	Ni	
	ALU 99,9 %							for pipelines + tanks (100% HNO_3)
1.4450	10CrNiNb189	0,12	0,40	0,30	18	-	9,50	for pipelines, tanks, heater (60 % HNO_3)
1.4016	8Cr17 (expired)	0,10	0,40	0,30	17,5			for pipelines, tanks, heater (45 % HNO_3)
1.4561	*) "Nictrothal 40"	0,12			20		34	for supportnet for catalyst
	Lead							for lining of tanks, pipelines, pumps
	Ferrosilicium		15					for dehydration column of HNO_3
1.3401	120Mn50	1,20	0,30	12,0				rollers in $CaCO_3$ mills
1.7335	13CrMo44 (or Alcal)*)	0,13	0,30	0,60	0,90	0,50		for lye pipelines and drums
	*) DUR 600							for welding and to armour
1.4828	15CrNiSi2012	0,20	2,0	0,60	12,0			baskets in NH_3-burners
	Teflon*) PTFE							for linings (special applicatio & gaskets)

*) Registred Tradenames

Drying of Calciumsulfat



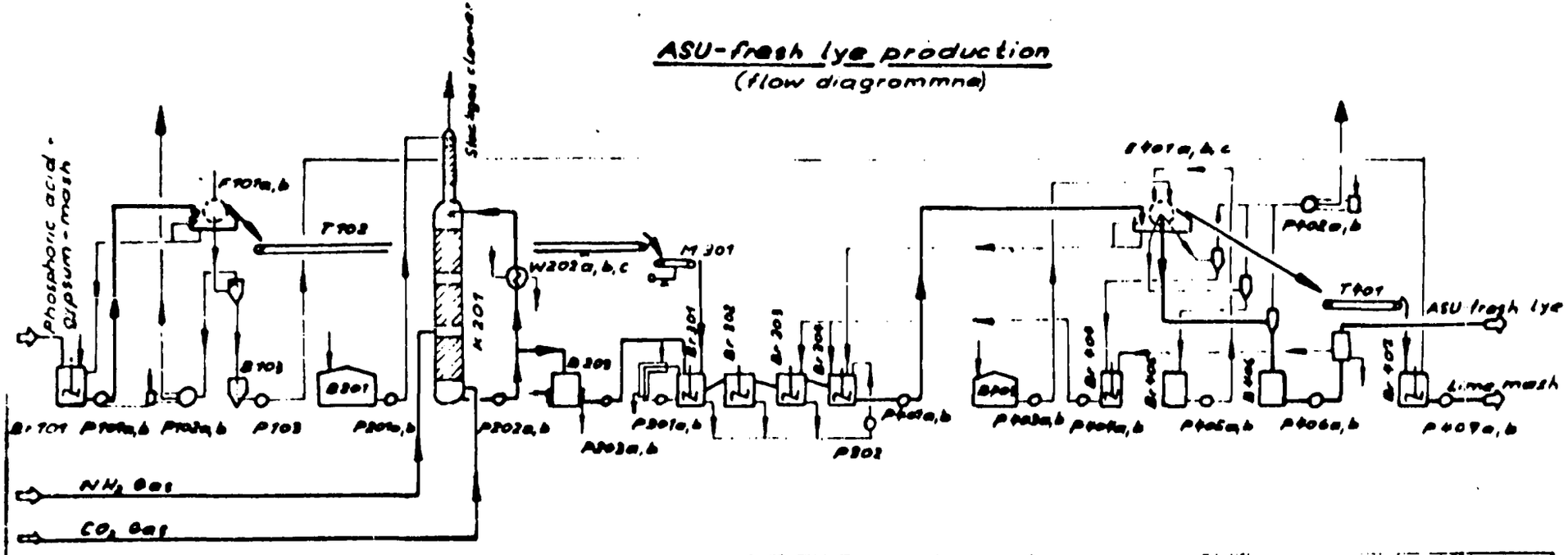
Phosphoricacid-
Ca-Sulfat-preparation

Production of
Amoncarbonate production

Gypsum-
Transformation

Calziumsulfatfiltration

ASU-fresh lye production
(flow diagrommne)



Br101 Melting vessel with agitator	B201 Processwatercontainer	M301 Scale on conveyor belt	P401 Mash pump	B405 Vessel for filtrate
P101 Mashpump	P201 Processwaterpump	Br301 Mixingvessel with agitator	F401 Filterdrum with vacuum	P405 Filtrate pump
F101 Filter drum with vacuum	K201 AC-Lyetower	P301 Circulatingpump	T401 Conveyor belt for filtered lime	B406 ASU-fresh lye container
P102 Vacuumpump	P202 AC-Lye--circulating pump	Br302 Reaction vessel with agitator	P402 Vacuumpump	P406 ASU-fresh lye pump
T102 Gypsum Conveyorbelt	W202 AC-Lyecooler	P303 Pump	F402 Ceramic filter	Br407 Lime mash vessel + agitator
B103 Vessel for filtration	B203 Ac-Lyevessel	Br303 Reaction vessel with agitator	B403 Washwater vessel	P407 Lime mashpump
P103 Pump	P203 AC-Lyepump	Br304 ——"——	P403 Washwaterpump	
			Br404 Container for filtrate with a agator	
			P404 Pump for filtrate	

4. UNIDO-Workshop

HISTORY OF PHOSPHATE - FERTILIZER - PLANTS (APP - ATP)

1954: Start of gypsum-sulphuric acid plant (production of sulphuric acid and cement from anhydrite).
Single superphosphate (now low demand)
Storages, bagging and shipping stations.

1958: Mixed fertilizers (closed after start of NPK-plant)

1958: Sulphur burning plant (Monsanto). Continuous improvements and expansions to increase capacity

1964: NPK - plant (1 granulator, 12 reactors, 1 cooler) - PEC process

1966: Phosphoric acid plant, prayon process.

1967: First expansion of NPK - plant (plus 1 granulator and 6 reactors)

1969: New NPK-storage with conveyor bridges, bagging and shipping in the south area of the company.

1970: Second expansion of NPK-plant (plus 1 cooler and some improvements).

1972: Heat exchanger for raw meal in gypsum sulphuric acid plant.

1973: Third expansion of NPK-plant (1 granulator, 14 reactors, 1 cooler).

1978: Second belt conveyor from NPK-plant to storage.
Equipment to use valve-bags

1979: Second economicer for Monsanto plant.

From start-up of the plants up to now have increased the capacity of the different facilities by removing bottlenecks, for example:

Monsanto plant	:	Layout	75 t/day H_2SO_4
		Actual	180 t/day H_2SO_4
Phosphoric acid	:	Layout	60 t/day P_2O_5
		Actual	130 t/day P_2O_5

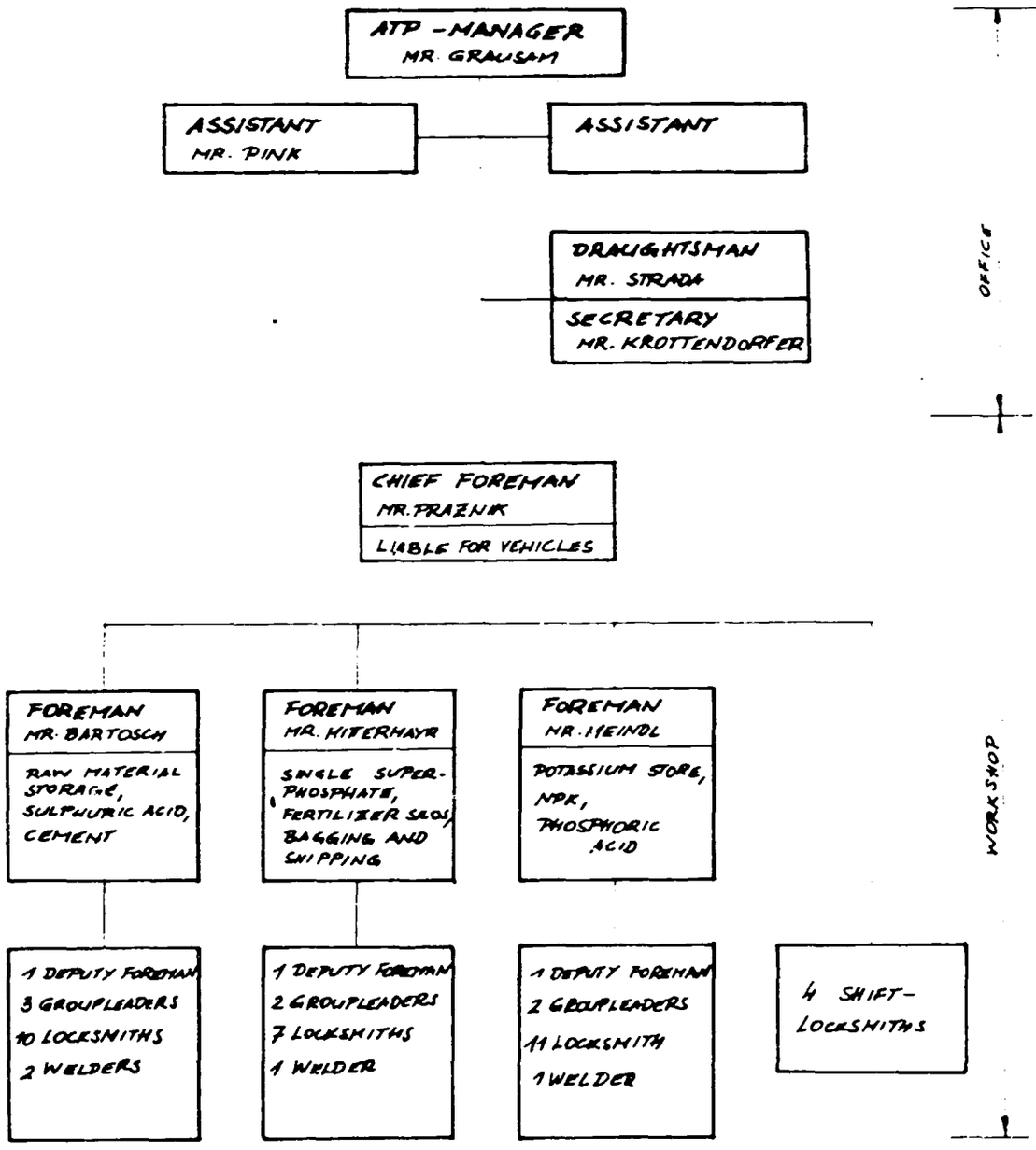
Due to good operation and good maintenance the percentual operating time of all our facilities is very high (100 % = 364 days per year) :

Examples:

	1977	1978	1979	1980
Gypsum sulphuric acid plant	96 %	95 %	96,1 %	97,6 %
Monsanto plant		98 %	97,3 %	94,8 %
Phosphoric acid plant	94 %	93 %	93,9 %	93,9 %
NPK - plant I	96 %	94 %	96,1 %	95,1 %
NPK - plant II	93 %	95 %	96,7 %	95,1 %

· ORGANISATION DEPT. ATP

A ..... DIVISION A (AGRICULURAL CHEMICALS)
T ..... TECHNIC
P .... PHOSPHATIC FERTILIZERS



THE FOREMEN ARE ALLOCATED TO CERTAIN PLANTS.
THE WORKERS - IF NECESSARY - ONE CAN SHIFT BETWEEN THE 3 FOREMEN - GROUPS

RESPONSIBILITY AND TASKS OF DEPARTMENT ATP

Surveillance, check, maintenance, repair of different production units, stores raw material and final products, bagging and shipping, laboratory.

Spare parts particulary used only for a special purpose in one, two or three departments - order, record, store, use.
Common spares like screws, bolts, . . . are in the central store.

Drawings: Draughtsman for sparepart-drawings, modifications in the plant, sketches. Small projects are made by the department, larger projects are made by the design-department. Drawings of design-department must be signed by the concerned maintenance and production departments. Record of drawings.

Contacts with outdoor companies, agents and reoresentatives, suppliers of spares, machines,...
Visit to suppliers. Correspondence with different companies, filing of correspondence.

Prospects, leaflets about special machines, parts, technics, materials used in the department

Contacts with other departments of Chemie Linz concerning repair, investment, production, design, finance,....

Supervision of delivery dates concerning spares, outdoor repairs, ...

Elaboration of shutdown-programmes in co-operation with production and central-departments.

Safety in the workshop and for all field repairs. The whole equipment has to operate in a safe condition.

Safety instructions according to the Austrian law (one time per year),accident-notice.

Information of foremen and staff, other departments, superiors,...
Daily, weekly, monthly, quaterly,...

Investment programmes of small volume, repair programmes, estimation of costs.

Cost control for maintenance, monthly computer prints, quaterly reports to division (comparison precast - aqtual).

Collecting of literature and papers concerning used operations, machinery and processes.

Training of foremen and workers in the field of technical knowledge, safety, efficient performance of repairs,....

Experiments and tests of new parts and products.

Co-ordination and co-operation with production department (daily morning discussion)

Calculations concerning machines, parts and the process.

Energy conservation (e.g. screw compressor - new or repair ?)

Engineering, process variables, physical chemistry

Accomplishment of authority-orders like pressure tests, yearly check of conveyors, earthing measurement of tanks for burnable liquids.

Obligations concerning pollution control (oil, waste gas treatment, . .)

Mutual control between maintenance and production departments resp. central depts.

Participation on seminars, courses, study of literature, visit of industrial fairs (e.g. ACHEMA,...) to improve technical knowledge.

Expert for suggestion system

Personnel problems - salary, transfer to other departments, overtime, . . .

Jobs as adviser or start-up personnel in Austria or a foreign country.

Training of people from other companies.

Showing of plants to our customers and other intrested groups (schools,...)

Collection and filing of experience, repair cards,...

Stand-by or on-call service from friday to monday
1 engineer or foreman
2 locksmiths

ACTUAL PROGRAMMES, PROJECTS and PROBLEMS for department ATP

Wheel loader with 1 m^3 shovel
Loading conveyors for very long wagons
Palettizer for open air storage, unit 634

Replacement of fork lift truck
Replacement of dumpers by a wheel loader - 3 m^3 shovel
Replacement heat exchanger VI - sulphuric acid plant
Replacement hot gas filter - monsanto plant
Replacement phosphate scale - phosphoric acid plant
Improvements on bulk loading systems - 620a and 633a
Speed-controllers for belt conveyors
Belt conveyors for coke
Unloading and loading of ships
Asphalt for open sulphur storage
Dose of trace elements
Improvement conversion in Monsanto plant
New sulphuric acid plant - double absorption
Sound protection - unit 601
Dose of coating agents (siliceous earth)
Lacerating machine for paper bags
Dedusting units for phosphate and potassium
Second palettizer for unit 634 (open air storage)
Scales for bulk product
Replacement cement bagging machine
Tank for AS - lye
Utilization of sulphur concentrated iron oxide
Preparation of hot water for division C
Bulk loading into vessels
Replacement KSB - compressors
Extension silo, bagging and shipping - unit 633
Coal dust combustion for cement kiln
Utilization of acid-oil in the kiln

Dedusting of waste gases of spheradizer I and II
Sale of caterpillar (tracked vehicle)
Removal of fertilizer-rests from boxes - nearly empty - unit 633
Utilization of excess steam
Pipeline for sulphuric acid between the units 608 - 626 - 627
Covers of eternit on conveyor bridges
Cleaning of cement silos
Investigations about use of palettizers in unit 620 a
Investigations about corrosions on spherodizers
Reduction of P_2O_5- and F-content in by product gypsum

Repair painting of conveyor bridges
Roof repair of clinker storage
Repair of chimney sulphuric acid plant
Repair painting - unit 631
Repair or replacement of electrostatic wet gas precipitator

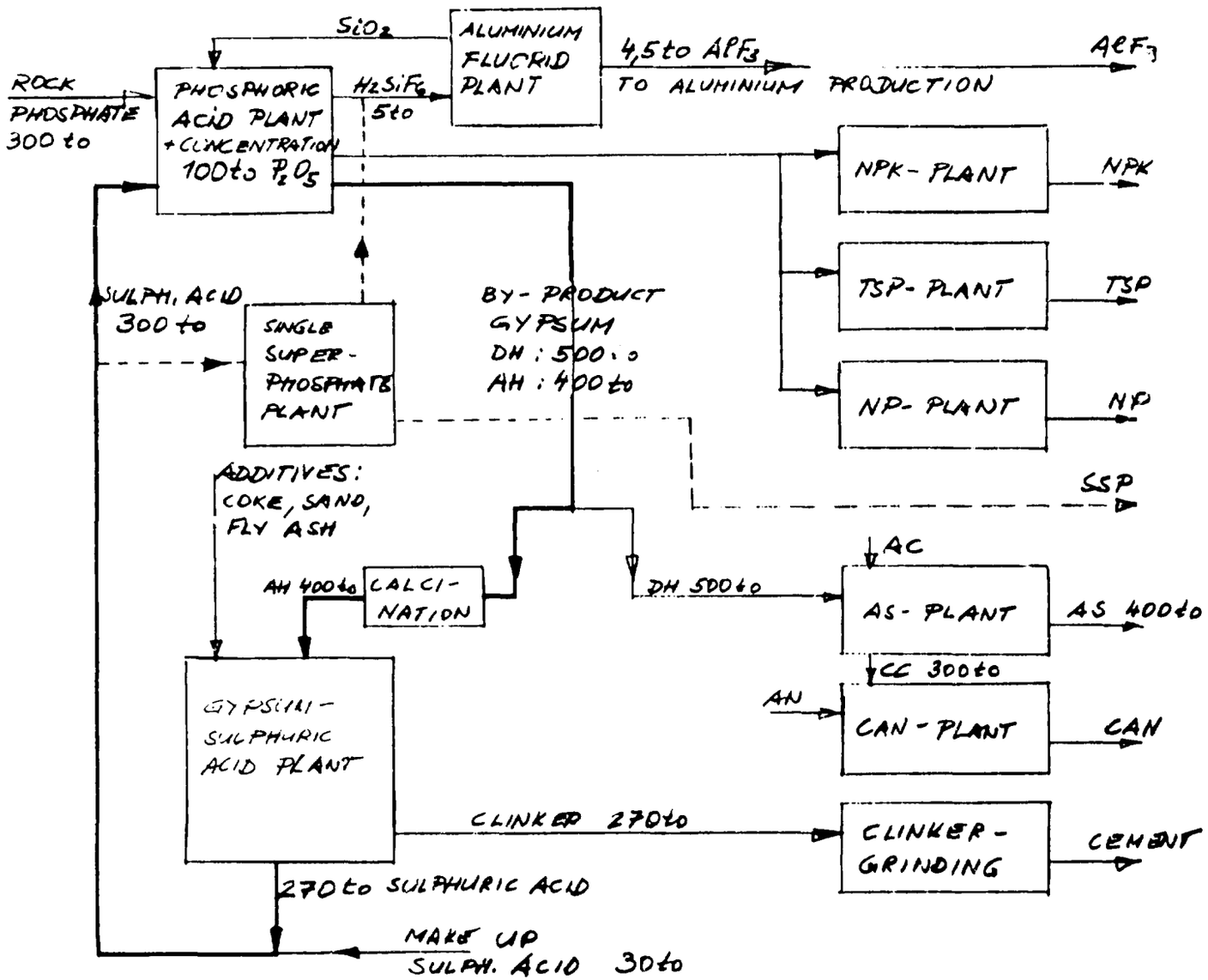
POSSIBILITIES TO REDUCE SHUT-DOWN-TIMES

AVOIDANCE OF BREAKDOWNS AND TROUBLES - EXAMPLES

LONG STOPPAGE TIMES DUE TO:	DECREASING RESP. AVOIDANCE OF STOPPAGES	EXAMPLE	PLANT
1) CLEANING OF THE PLANT	MODIFICATION OF OPERATION	H_3PO_4 - TANK, FILTER HEAD	PA
	CLEANING DURING OPERATION	HAMMERS ON SPHERODIZER	NPK
	MODIFICATION OF CONSTRUCTION	CONSTR. BELOW ROLLER CRUSHER	NPK
	USE OF MORE PERSONNEL (ORGANISATION)		
	CLEANING PROCEDURE	CLEANING OF KILN (BURNING/CO_2/GUN/H_2O)	G-SA
	CLEANING DEVICE	PNEUMATIC TOOLS FOR CYCLONS	NPK
	IMPROVEMENT OF WORKING CONDITIONS	PODESTALS, ADDITIONAL WORKING FLOORS	G-SA
	PROTECTIVE DEVICES	GRID IN DUCT SPHERODIZER CYCLONS	NPK
	AVOIDING OF CLEANING POINTS	DRUMS OF BELT CONVEYORS (RUBBER COVER, BAR-DRUMS)	
		INSULATION OF SCAVENGING-AIR-DUCTS TO FILTERS (CONDENSATION)	
2) CHANGING OF PARTS DUE TO WEAR CORROSION FATIGUE	USE OF SUITABLE MATERIAL	DELBAG FILTER (STAINLESS STEEL)	NPK
		TEFLON-LINED MIXER	SA
		ARMOUR PLATES (BOFORS, Cr.) FOR MILLS	CEMENT
	INCREASING WALL THICKNESS	INLET-ARMOUR PLATES	CEMENT
	IMPROVED CONSTRUCTION	VIBRATION-CRACKS ON REACTORS	NPK
	CHANGING PROCESS	WELDING OF WASTE GAS: STEEL → PP	SA
3) OVERLOAD: MECHANICAL THERMIC ELECTRIC	CHANGING OPERATING CONDITIONS	ROLLER BRUSHER → IMPACT CRUSHER	NPK
	EXACT LAY-OUT	SHEAR PIN BUCKET ELEVATOR	STORAGE
	CONTROL - SWITCH OFF	SPEED CONTROLER (CRUSHER-ELEVATOR)	NPK
	WELL TIMED SHUTDOWN	HOT SPOTS ON KILN SHELL	G-SA
	GENEROUS LAY-OUT	DUST FILTERS	NPK
	STRENGTHENING OF PARTS	SCREW CONVEYORS FOR POWDERING AGENT	NPK
	PROPER OPERATION		

LONG STOPPAGE TIMES DUE TO	DECREASING RESP. AVOIDANCE OF STOPPAGES	EXAMPLE	PLANT
4) UNPROPER OPERATION DUE TO	MORE ATENTION	TROUBLE WITH CATERPILLARS	SILO
- IGNORANCE	BETTER KNOWLEDGE (TEACHING, TRAINING)	SWITCH GEAR FOR KILN	G-SA
- CONVENIENCE OF OPERATOR	MORE EXPERIENCE	RECIPROCATING SULPHUR PUMP	SA
- FEAR, FRIGHT	PROPER PLANNING	KCl (POTASSIUM) IN REACTORS 1+2	NPK
- LACK OF TIME	COMPREHENSION OF SUPERIOR FOR PRODUCTION LOSSES	⋮	
5) NO IMPROVEMENTS	DON'T FIGHT AGAINST TROUBLES, TRY TO AVOID THEM	CLEANING OF SPHERODIZERS	NPK
- IN PROCESS	OBSERVATION ON THE SPOT - SUBSEQUENT CONCLUSIO		
- ON MACHINES	GOOD CONTACT WITH OTHER DEPT. (EXCHANGE	SCREW CONVEYORS WITH RUBBER TROUGH	NPK
- IN REPAIR TECHNOLOGY	OF EXPERIENCE AND KNOWLEDGE)		
	COURAGE TO EXPERIMENTS	LAB - PLANT	
6) FALSE REPAIR	GOOD KNOWLEDGE OF MACHINES		
	GOOD KNOWLEDGE OF PROCESS		
	COMPARISM OF DIFFERENT REPAIR METHODS	BOTTOMS OF DRYING-AND ABSORPTION-TOWER	SA
	THINKING ABOUT ECONOMY		
	PREPARATION OF A REPAIR	TIMETABLE, SHUT DOWN PROGRAMME	
	CARE FOR SPARE PARTS		
	ESTIMATE OF REPAIR VOLUME AND TIME REPAIR FOR		
	SUPERVISION OF MAINTENANCE		
	IDENTIFY FAULT BEFORE SHUT-DOWN		
	DISCUSSION OF REPAIR WITH LOCKSMITH BEFORE START		
7) GENERAL ITEMS	FILING OF EXPERIENCE	REPAIR CARDS	
	KNOWLEDGE OF LIFE-EXPECTANCY → OVERHAUL-CYCLES	MEASUREMENT THICKNESS OF WEAR-PARTS	
	KNOWLEDGE OF TROUBLE-SYMPTONS (NOICE, TEMPERATURE, LENGTH, AMMETER, ...)	⋮	
	PREVENTIVE MAINTENANCE DURING OPERATION		
	WORKING CLIMATE IN THE GROUP		
	FINANCIAL STIMULUS (PERSONNEL MOTIVATION)	ADDITIONAL ALLOWANCE (DUST, NOICE, ...)	

CIRCUIT OF SULPHURIC-ACID



DH .... GYPSUM DIHYDRATE
AH .... GYPSUM ANHYDRITE
AC .... AMMONIUM CARBONATE
AN .... AMMONIUM NITRATE
AS .... AMMONIUM SULFATE
CC .... CALCIUM CARBONATE

IAP / MR. DUBOWY
ATP / MR. KRAUSAM
1979 06 18

MAINTENANCE COSTS DEPT. ATP
COMPARISON : PRECAST - ACTUAL, 1. QUARTER 1981

COST CENTER	UNIT	PRECAST 1981 1. QUARTER	ACTUAL 1981 1. QUARTER	DEVIATION AMOUNT	DEVIATION %
1201	SULPHURIC ACID - MONSANTO	1,175.000,-	853.000,-	- 322.000,-	-27,4
1202	GYPSUM SULPHURIC ACID	5,000.000,-	4,443.000,-	- 557.000,-	-11,1
1203	CEMENT	835.000,-	1,084.000,-	+ 249.000,-	+29,8
1204	SUPERPHOSPHATE	985.000,-	1,126.000,-	+ 141.000,-	+14,3
1205	PHOSPHORIC ACID	1,990.000,-	1,910.000,-	- 80.000,-	- 4,0
1206	NPK	5,405.000,-	6,037.000,-	+ 632.000,-	+11,7
1221	SILO WEST	755.000,-	456.000,-	- 299.000,-	-39,6
1222	SILO SOUTH	465.000,-	407.000,-	- 58.000,-	-12,6
1224	CEMENT SILOS	250.000,-	285.000,-	+ 35.000,-	+14,0
1227	BAGGING + SHIPPING	5,005.000,-	5,353.000,-	+ 348.000,-	+ 6,9
1228	CEMENT BAGGING	290.000,-	692.000,-	+ 402.000,-	+138,6
1229	CENTRAL RAW MATERIAL STORAGE	621.000,-	586.000,-	- 35.000,-	- 5,6
1230	DEPT. LABORATORY	120.000,-	113.000,-	- 7.000,-	-5,8
1916	ATP - WORKSHOP	111.000,-	105.000,-	- 6.000,-	-5,4
	TOTAL	23,007.000,-	23,450.000,-	+443.000,-	+ 1,9

ATP/1.Quart./Lima

COMPARISON of maintenance costs
1. quater 1981, department ATP

1201 – Sulphuric acid – Monsanto plant -27,4%
General shutdown planned for June 1981

1202 – Gypsum sulphuric acid plant -11,1%
General shutdown planned for September 1981

1203 – Cement +29,8%
Routine check and overhaul in winter time.
General overhaul of clinker crane.

1204 – Superphosphate +14,3%
Wooden front sides of the buildings 621 and 622 are in repair (programme roof-repair by civil dept.). Change of granulation from granulator 1 and 2 to granulator 3 and 4.

1205 – Phosphoric acid - 4,0%

1206 – NPK production +11,7%
Repair and painting of NH3-, natural gas- and water pipelines, preparation repair of spherodizer III (ring, lifters), installation of new metering device for H3PO4.

1221 – Area silo west -39,6%
Repair programme of roof-top not yet realized.

1222 – Area silo south -12,5%

1224 – Cement silos +14,2%
Overhaul in winter time

1227 – Bagging and shipping + 6,0%
Training on and start of palettizing unit - higher costs by departments ATP, TEL, TVE.
Repair of reclaimer chain by THW.
More breakdowns on loading vehicles.

1228 – Cement bagging +138,6%
Overhaul of complete bagging and loading station in winter time.
Gauge of cement bagging machine.

1229 – Central raw material storage -5,6%

1230 – Department laboratory -5,8%

1916 – ATP-Workshop -5,4%

SAFETY MEASURES FOR THE COMPLEX FERTILIZER STORAGE AT CHEMIE LINZ PLANT SITE

A. PRODUCT

- complex fertilizer (NPK) or occasionally CAN (28 %) with max. 0,4 % C.
- storage feed temperature max. 50° C. Continuous measurement by means of two independent thermocouples. Temperature is indicated and recorded with max. alarm in the control room of complex fertilizer plant.

B. DESIGN MEASURES

1. Belt conveyors

- belts within the silo in flame-adverse material
- speed controler (shut off)
  straight running control (alarm)
  emergency switch with pull lines (shut off)
- lower belt temperature-control by pyrometers for the storage feed conveyors
  (alarm in the control room of the silo)
- division of the belt bridge into fire fighting sections by means of waterspray-curtains
- emergency exits (ladders) marked by arrows (always two exits for each belt bridge in addition to the stairs in the corner stations)
- metal detector before the entrance of the silo (shut off of conveyors) and additional magnetic metal-pick-up at the way out of the complex fertilizer plant

./2

- swivel chute located in the last delivery station before the silo for discharge of the belt conveyor to the open air.
- arrangement of the belt conveyors so that they cannot be an initial heat source for the fertilizer
- fire extinguishers (CO2) within a distance of 35 m along the belt system
- telefon system with connections in a distance of 100 - 150 m
- interlocking of all belt conveyors to ensure shut down of preceding conveyors in case of failure.

2. Silo

- partition to 12 boxes, each with a max. capacity of 5 000 t.
- thickness of partition walls designed that in case of a decomposition in one box ignition in a neighbour box due to heat transfer is not possible.
- all civil engineering material used is flame resistant
- feed product is screened by gratings to remove lumps
- heat sources like steam supply lines and electrical cables are not in contact with the fertilizer
- electrical equipments are mounted sidewards and designed in wet-room-standard.
  Main switches are outside of the silo.
- lightning rods protect the silo
- emergency orientation lights in the roof top of the silo, along the reclaimer path and in the lateral belt-channels (automatically switched on in case of power failure). No bulbs but only fluorescent tubes are used.
  Handlamps are not permitted.

./3

- windows for opening and closing along the roof top (5 % of the ground floor area).
  All windows are remote-controlled from outside the silo by a separate supply of compressed air and daily operating tests.
- emergency exits from the roof top, the reclaimer pathes and the conveyor bridges marked by arrows
- extinguishing line (dry) for fire water in the head building of the silo
- flooding line for each belt channel with a capacity of 2,5 m^3/min.
- hydrants outside the silo connected with a ring system of 600 - 400 mm diameter
- 12 mobile water canons each for 1,5 m^3/min adjustable for spray or jet application
- free outlet of product slurry after opening of the doors on the end of the belt channels
- emergency exits from the lift
- separate repair box for repairs on the reclaimer and jobs with fire.

C. MEASURES BY ORGANISATION

- general strict prohibition of smoking
  exception: dayrooms, office of supervisors, workshop and control-room in the head building of the silo
- repair jobs are only allowed in accordance to the written "job permit"
- welding within the storage silo only under special supervision and not near the product. Control of the spot for 6 hours after finishing of the job by means of an infrared-instrument.

./4

- operating manuals for all working places, safety instructions every half a year
- control of the storage silo every half an hour recorded by means of a printing-watch and control book
  wireless contact of the control person to fire-brigarde
- sufficient respirators for compressed air and gas masks, most of the operating personnel is trained in heavy gas protection
- free access for the trucks of the fire brigade
- warning plan (sequence) in the case of danger
- shovels and buckets are available

FACTS ABOUT STORAGE SILO FOR NPK - UNIT 633

length 186 m
width 53 m volume of the building: 125.000 m^3
height 22 m

12 boxes, each 5000 tons = 60.000 tons storage capacity
repair box for reclaimer
possible extension: 4 boxes each 5.000 tons = 20.000 tons

max. storage height 14 m wall thickness between the boxes: 1 m
max storage width 43 m number of gates to the storage : 24
max storage length 14 m

Mechanical equipment:

2 reclaimers delivered by SCHADE (Western Germany), each for a capacity of 180 t/h.
weight of one reclaimer: 40 t

capacity of feed conveyors : 2 x 60 t/h
capacity of reclaimers : 2 x 180 t/h

Head building with control room, screens and crushers

length 46 m
width 15 m
height 27 m

Bagging and shipping

length 106 m
width 19.5m width of the loading ramp 9.6 m
height of towers 24 m

Mechanical equipment: 2 bagging and shipping stations, each for 60 t/h bagged product and 60 t/h bulk product

Belt conveyors -	feed conveyors to storage silo	2336 m
	conveyors between silo and bagging station	700 m
	conveyors for wagon loading	56 m
	conveyors for ship loading	777 m
	conveyors to open air storage	35 m
	total	3904 m

Energy supply

electrical energy 800 kW installed power
drinking water
separate station for compressed air
steam supply
fire water supply over 14 hydrants

supervision and control from 2 control rooms
the whole plant is equipped with dedusting filters of high efficiency
additional railway lines 4500 m
additional streets 650 m
2 dayrooms for operating personnel, rooms for supervisers, modern sanitary facilities

information

CHEMIE LINZ AG

General guidelines for fertilizer storages

Under normal transport- and storage-conditions mineral fertilizers are wether explosive nor self-flammable.

In general it is sufficient to hte fertilizer dry and clean to avoid contact of different products and in consequence chemical reaction of the mixtures.

Fertilizers with ammonium-nitrate (e.g. CAN,NPK) can decompose under influence of extern fire or heat at temperatures above 130 °C. Decomposition will proceed slowly without extern heat supply through the total fertilizer mass. A yellow-brown, pungent smelling, poisonous smoke will be developed (nitrouses gases - dangerous breathing-poison).

Preventive safety measures

If the following recommendations are observed the danger of thermal decomposition can be excluded certainly. In case of fire in a storage decomposition can be avoided with high propability.

Please observe:

1) Clean storage rooms before storing of fertilizer containing ammonium-nitrate. In particular follow this instruction for bulk-stores.

2) Burnable products e.g. coal, sulphur, corn, oil and fuels also acids, unslaked lime, CAN and thomas-phosphate are not allowed to mix with fertilizers and are to store separately.

3) Smoking and use of fire or open light is prohibited in the storage room (also welding, soldering,...)

4) Take provisions that ammonium-nitrate-containing fertilizers can not be heated from outside. Steam lines (even if insulated), electrical cables, electrical motors and heat producing lighting fixtures also hot exhaust gases of vehicles may not come in contact with fertilizer.
   Also there must be a guarantee that conveyors for fertilizer transport can not run hot.

5) Should occur a fire in the area of the warehouse immediately the fire origade must be informed in which buildings fertilizer containing ammonium-nitrate is stored to protect such fertilizer stores against fire in the best way.

information

CHEMIE LINZ AG

Guidelines for successful fight against thermal decomposition of NPK-fertilizer

The necessity of the use of labour-saving products in the field of agriculture leads to fast increase of the demand for mineral fertilizers in general and NPK-products in particular.

These fertilizers are not explosive or self-flammable under normal transport- and storage-conditions. Complications are not to expect.

NPK-fertilizers containing ammonium-nitrate can decompose slowly at temperatures above 130 °C particulary due to influence of fire. At some fertilizers decomposition will stop if heat transfer from outside is stopped. Other formulars can decompose completely over the whole mass of stored fertilizer and can develope a large volume of hot nitrouses gases (350 °C) and water vapour.

The gases are poisonous, the fight against hot spots can only be performed by use of breathing devices (in the open with B/St- or F/St-filters, in closed silos as well as in areas of high concentrations with heavy breathing devices).

NPK-fertilizers mostly are stored in paper- or plastic-bags. An interruption of the reaction by water irrigation of the bag-piles will not be expected. The most secure method to avoid extension of the hot spot is to divide concerned mass of fertilizer from the rest, to transport it to the open air and to make full use of water spraying to stop reaction.

In case of decomposition of bulk fertilizer it can be brought to open air at an early stage of reaction (e.g. by shovels). Another way is to spoil out the endangered amount of fertilizer by means of a strong water jet.

ATTENTION: The fight against decomposition by other measures (e.g. foam, carbon dioxide, steam, cover with sand or fertilizer) is useless. Decomposition even can be accelerated by such measures.

In case of decomposition of palletized material fork lifts can be used to remove the concerned piles to the open air. Under certain circumstances wetting of the storehouse can be avoided. There is no danger for explosion for the fork-lift-driver. But he has to wear breathing devices.
After some time of reaction the bags will fall to pieces. The decomposing fertilizer then can be spoiled by a strong water jet.

Poisoned persons are to lay with the face to the ground, body in half-side-position, keep the person warm and calm and provide a doctor immediately. Wash eyes and mouth with neutralizing products (e.g. bicarbonate of 3 % concentration, but no boron-water), eventually start breathing with oxygen.

Guidelines about useful storage of mineral fertilizers are distributed to all warehouses , the final users (farmers) will be informed in a proper manner.

This information is distributed to all fire brigades of Austria.

MATERIALS used by ATP

7901 08 Rev

		CODE			COMPOSITION [%]										APPLICATION
		Mat. Number	International code	Abbrev.	C	Si	Mn	Cr	Mo	Ni	V	Cu	Nb	Ti	Examples
NORMAL STEEL		1.0401	St C 15 k1 61	C15	0,15	0,25	0,40								
		1.0501	St C 35. 61	C35	0,35	0,25	0,55								
		1.0503	St C 45 61	C45	0,45	0,26	0,65								
			St 35. 8 K		>0,13		0,65							P<0,03 S<0,05	CONVEYOR CHAINS (case hardened)
		1.3401	X 120 Mn 12	Chromos	1,2	0,4	12								REDLER
	HEAT RESISTANT	1.7258	24 CrMo 5		0,24	0,30	0,70	1,15	0,25						SHAFT FOR SO$_2$-gas exhaustor
		1.7335	13 Cr Mo 44		0,13	0,30	0,6	99	0,5						PADDLES FOR SPRÄHTROCKNER NPK
		1.7733	24 CrMoV 55		0,24	0,30	0,5	1,3	0,55						
HIGH ALLOYED STEEL	RUST- + ACID RESISTANT	1.4550	X10 CrNiNb 18 8	SAS2/AV6	0,1	1,0	2,0	18	-	10				(2)	[Mo+Ti ≥ 2%]	
		1.4571	X10 CrNiMoTi 18 10	3251 4	0,08			18	(2)	11				(2)	[Mo+Ti ≥ 2%]	REACTOR PARTS NPK
		1.4577	X5 CrNiMoTi 2525	AV8	0,06	1,0	2,0	25	2,25	25						H_3PO_4 - resistant
		1.4580	X10 CrNiMoNb 1810	SAS4	0,08	CA	1,2	18	2,25	11,5						REACTORS NPK
		1.4586	X5 NiCrMoCuNb 2213	SAS 10	0,07	0,65	0,8	18	32	22	/	2	-1			REACTORS NPK
			25 MnCrMo 52													CONVEYOR CHAINS
	HEAT RESISTANT	1.4871	X20 CrNiSi 25 4	FA	0,2	1	2	26	/	4,5						CONVEYOR CHAINS
		1.4828	X15 CrNiSi 2012	FF	0,15	2	2	20	-	12						
STEEL CASTING	WEAR-RESISTANT			GS 60	3,2 4,5											
				GG 18	4,8 3,3	1,2 1,9	0,8 1,2							P<0,3 S< 0,12		
				GG 25		4,8 3,0										MIXER FOR SINGLE SUPERPHOSPHATE (ROCK PHOSPHATE + H$_2$SO$_4$)
		1.3401	G-X 120 Mn 12	Chromos	1,15	0,4	12,5									ARMOUR PLATING OF BALL MILL
				BF 253				26	3							——"——
			Si-casting	Duracid		15			3							H_2SO_4 - pumps
	HEAT RESISTANT	1.4823	G-X 40 CrNiSi 27 4	[illegible]	0,4	1,2	/	27	/	4						COOLING SYSTEM OF KILN
		1.4832	G-X 25 CrNiSiNb 20 14		0,2	1,75	1,5	20	/	14						KILN - MATERIAL ENTRANCE
			MECHANITE HC		1,0	1,5	0,6	29				0,10			P<0,16	H_2SO_4 CONVERTER
	ACID RESISTANT	1.4401	G-X 5 CrNiMo 1910		0,04			19	2	11						Valves for H_2SO_4
		1.4312	G-X 10 CrNi 18 8	[illegible]	0,15	2	2	19	-	9						Cooling system of Kiln
		1.4411	G-X 5 CrNiMo 1810	[illegible]	0,05	2,5	2	18	2,25	10						——"——
		1.4435	G-X 2 CrNiMo 2712	Corrosit 30	0,05	2	1	28,5	2,25	-						H_2SO_4 - pumps
		1.4460	G-X 8 CrNiMo 27 5	[illegible]	0,1			27	1,5	5						NPK - pumps
		1.4470	G-X 5 NiCrMoCu [illegible]	[illegible]	0,04	1,5	2	20	3	25						H_3PO_4 Submerged pumps
					0,05	1,5	0,5							P< 0,04 S< 0,1		H_2SO_4 cooling pipes
			MECHANITE (A)		2,3	2,3	0,6	0,2				0,25				ALTERNATIVE parts of H_2SO_4

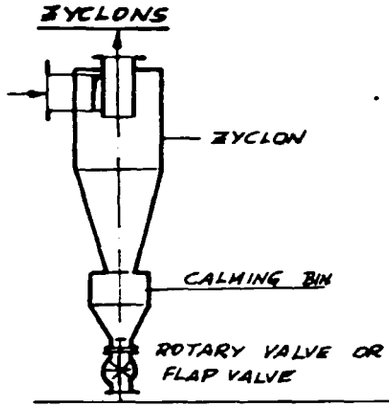
WASTE GAS - POLLUTION CONTROLL

a) Injunctions of authorities:
Due to the very closed location of Chemie Linz to the town of Linz we have very severe injunctions concerning pollution controll. In the planning state of a new plant we have to declare the volume, chemical analysis, dust content, temperature of all effluents. We are obliged to controll this effluents in a determined way and to show this notes to the authatities.
Examples: Continuous recording of SO_2-concentration of the waste gas in sulphuric acid plants. Dust determination at least four times per year. Analyses of effluent water from different points of the sewage-system.

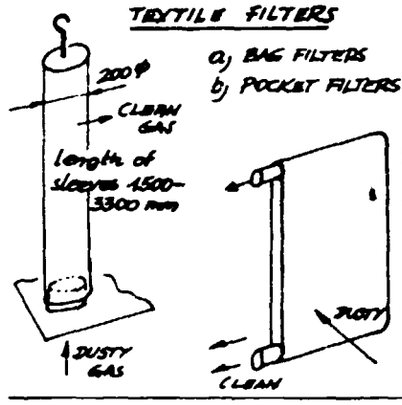
b) Methods of gas cleaning in dept. ATP

REMOVAL OF SOLID IMPURITIES

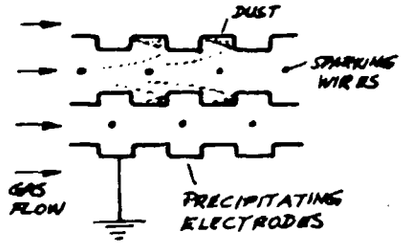
CYCLONS



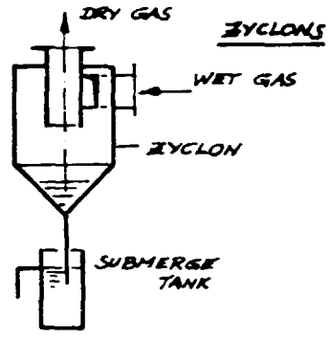
TEXTILE FILTERS



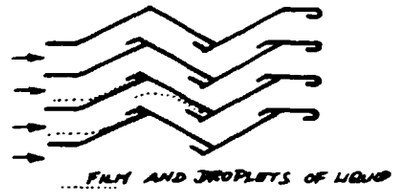
ELECTROSTATIC PRECIPITATORS FOR DRY GAS



REMOVAL OF LIQUID (AND SOLID) IMPURITIES

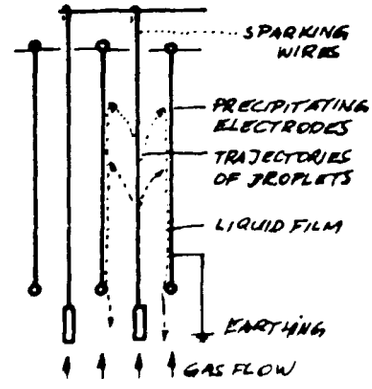


"EUROFORM" MIST ELIMINATOR



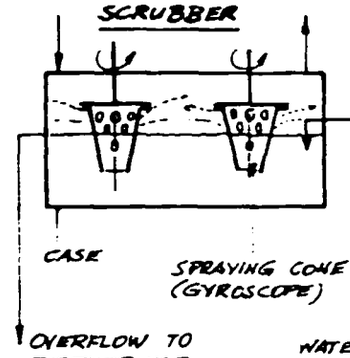
PLATES MADE OF METALS OR PLASTICS

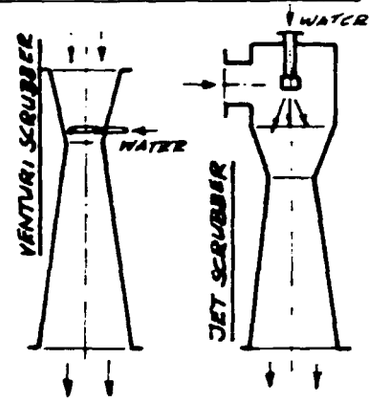
ELECTROSTATIC PRECIPITATORS FOR WET GAS

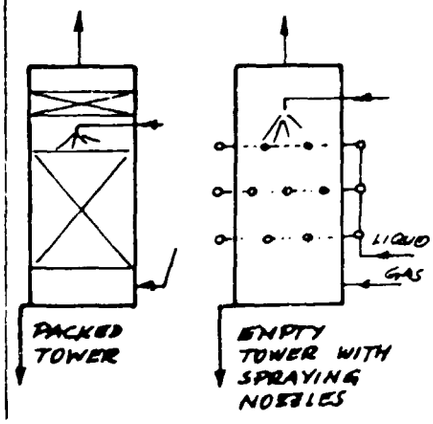


REMOVAL OF GASEOUS (SOLID + LIQUID) IMPURITIES

SCRUBBER

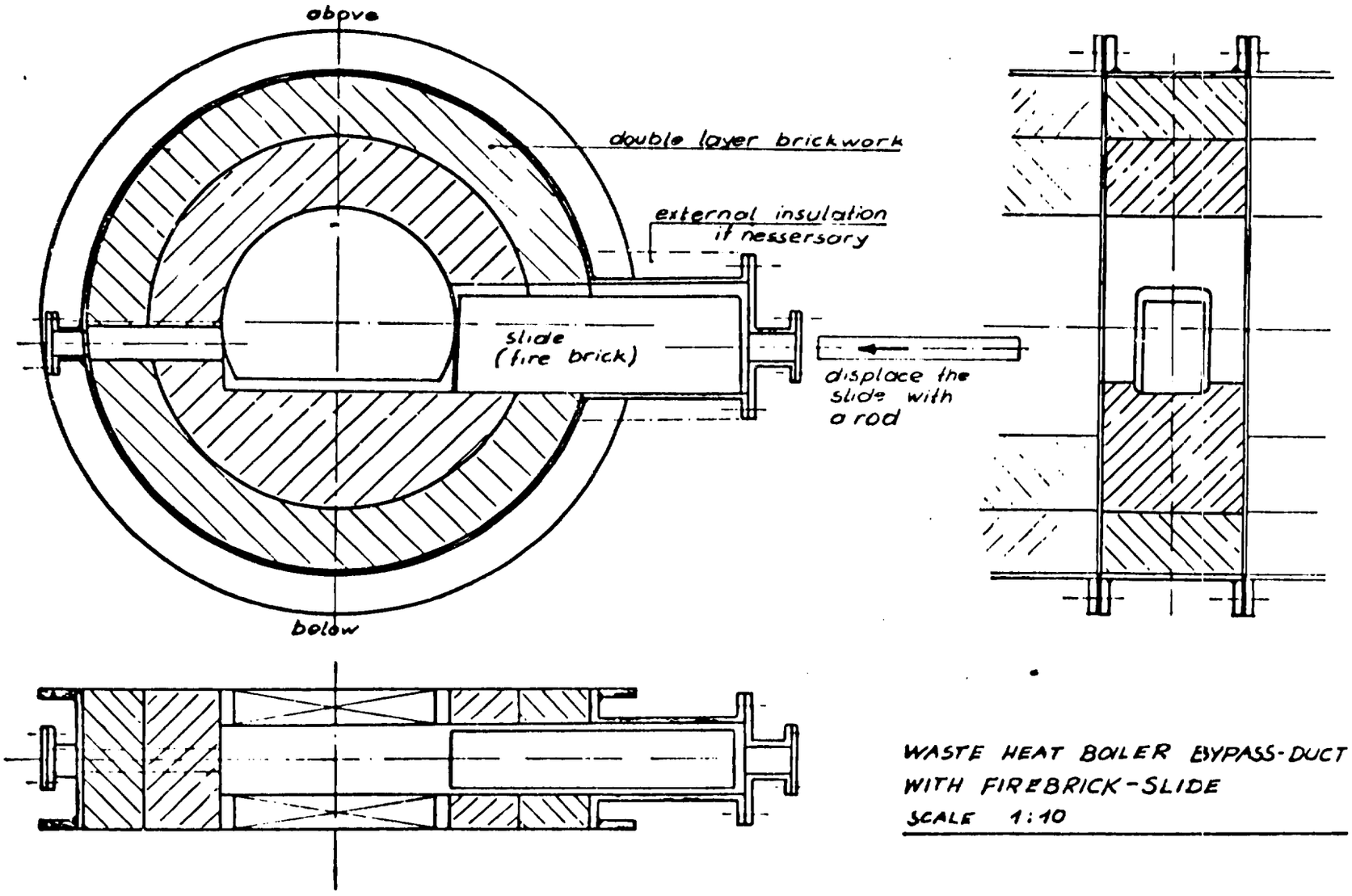






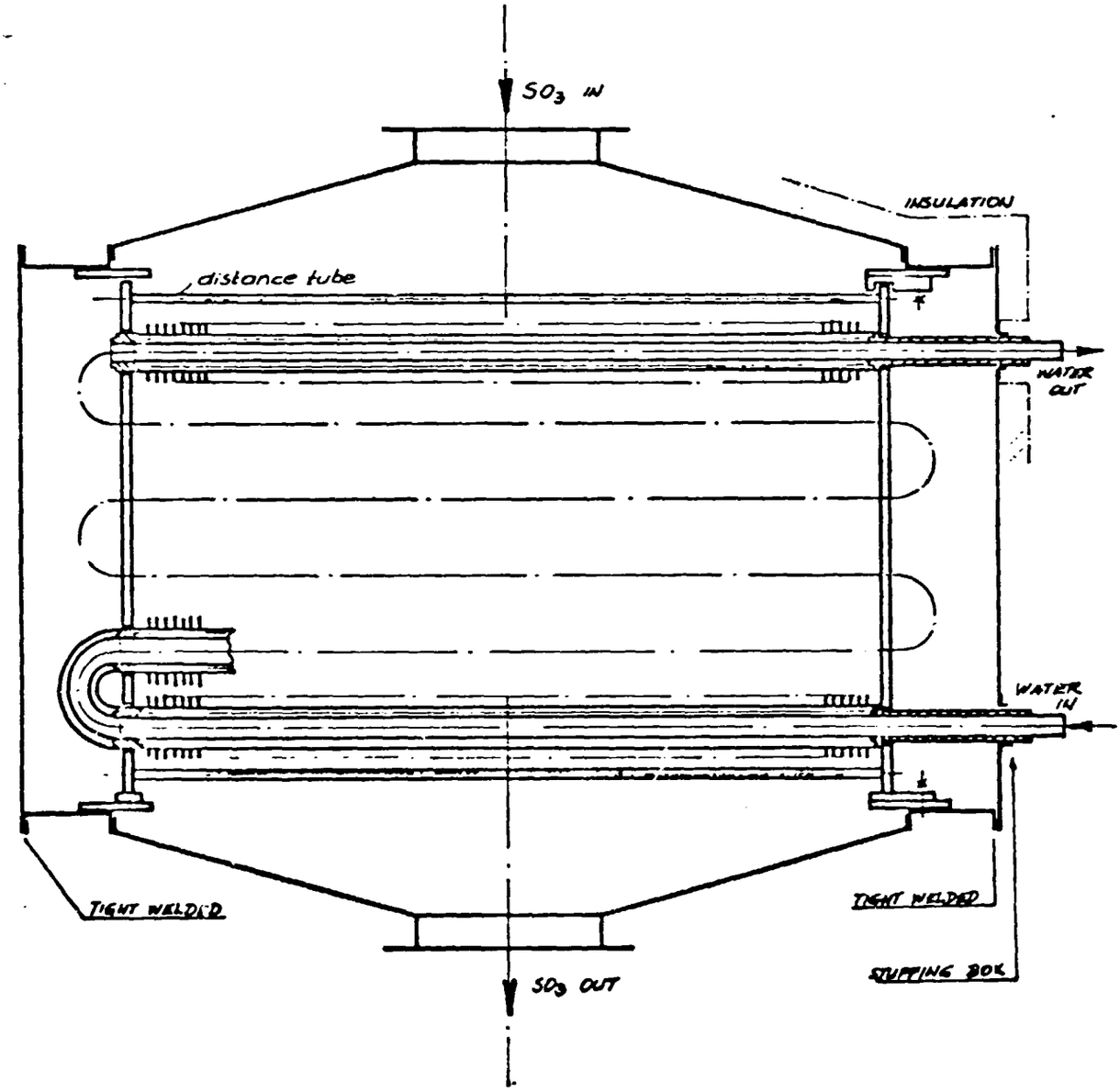
Responsibility:

There is a separate department in our company responsible for Chemie Linz internal pollution controll and competent for all the contacts to authorities.



WASTE HEAT BOILER BYPASS-DUCT
WITH FIREBRICK-SLIDE
SCALE 1:10

The scetched economizer is a construction of
Rheinstahl Eco GmbH.



Characteristics:

seamless steelpipes
fin-tubes of cast iron
two-piece elbows (cast iron) with asbestos sealing,
filling the hollow between interior and exterior elbow
with iron -file-chips.
housing gastight welded
water in- and outlet protected with cast iron and stuffing box.

The first ECO-design in the Monsant-plant of Chemie Linz AG was similar to the system at Chittagong. Since 1965 we have three steam generators between the passes of the converter (cooling the SO_2/SO_3-gas) and one economizer after the 4.pass in a construction as shown above. All tubes and elbows are inside the housing protected with cast iron against corrosion. We can recommend this system and we warn against a construction with flanges. In Europe there are only a few experienced manufacturer of this tubes i.g.

Foster Wheeler, Great Britain
Rheinstahl ECO GmbH, Hilden, Germany.

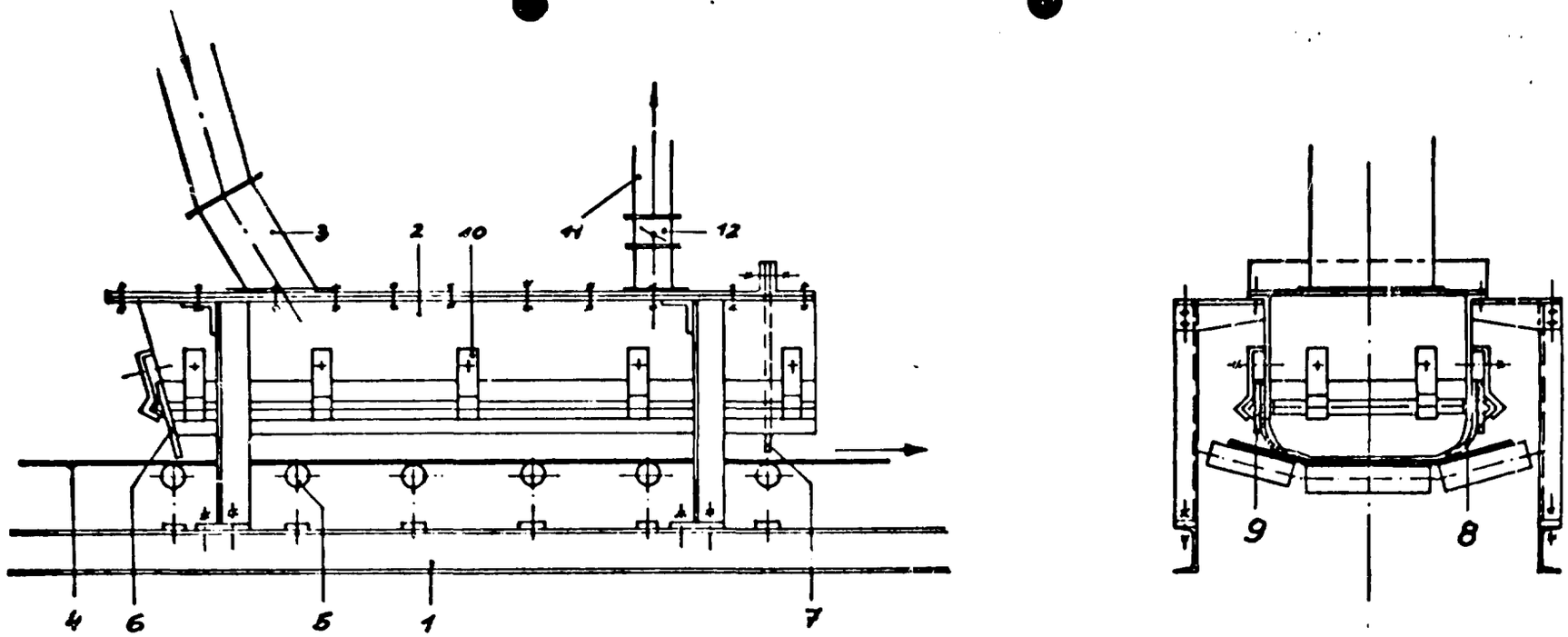
The steel pipes either will be shrinked into the cast iron fin-tubes or the diameter of the steel pipes will be increased in consequence of overpressure after fitting with the cast iron fin-tubes. The cast iron shield has to be very tight avoiding condensation and corrosion.

ACID-DISTRIBUTION:

In our acid plants we have different acid distributors:

Monsanto plant: Distribution cup with overflow weirs.
The material of the cup is Meehanite CB3 with <3.3% C, >2.7% Si, 0.6% Mn, 0.3% Cr, >0.5% Cu.

Anhydrite plant: Trough distribution system in cast iron with downcomers in ceramic. Experiments with downcomers in stainless steel 1.4580 and cast iron have been not satisfactory.



PRINZIPLE SKETCH OF A CLOSED AND DUSTFREE BELT-CONVEYOR DELIVERY-STATION
in the fertilizer plants of Chemie Linz AG and Donau Chemie AG.

1) conveyor frame
2) sheet metall housing
3) material feed duct
4) rubber belt
5) roller
6) rearward rubber apron, 12 mm thick
7) front rubber apron, 4 mm thick, soft rubber
8) lateral inside rubber apron, 4 mm thick, soft rubber
9) lateral outside rubber apron, 12 mm thick
10) clamp-bow to fasten the aprons
11) exhaust duct to a dust precipiator
12) butterfly valve to regulate the exhaust flow.

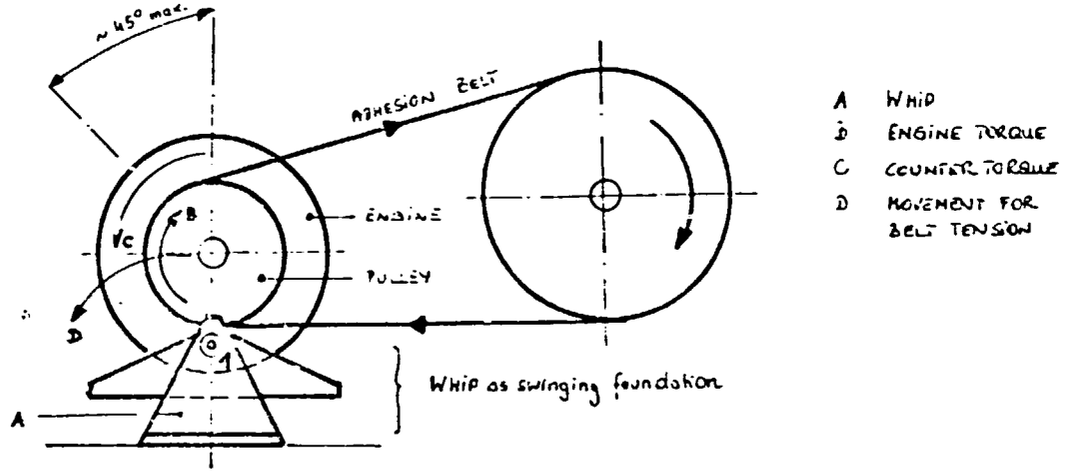
} all the aprons are readjustable

POWER STRIP - WHIP (electrodynamical belt tension)

automatic, load dependend, regulated belt tension

no slide slipping

best possible efficiency

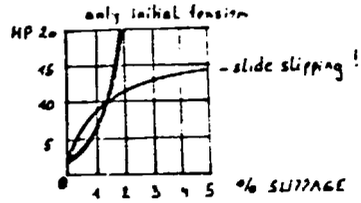


FUNCTION :

The engine torque B produces a counter torque of same size C , which causes a movement of the engine D around point 1 . This means extended shaft distance - and load depended increase of belt tension.
Best power transmission is managed by this turnable engine foundation in connection with polished-cambered pulley and special adhesion belt

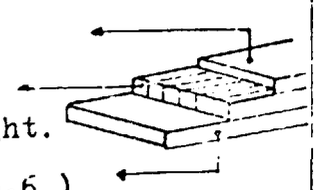
SLIPPAGE :

sliding slippage is not possible because of exact belt-tension adjustment by engine torque.
this means :
higher efficiency
lowerinitial belt tension
lower stress in shaft bearings
longer working period



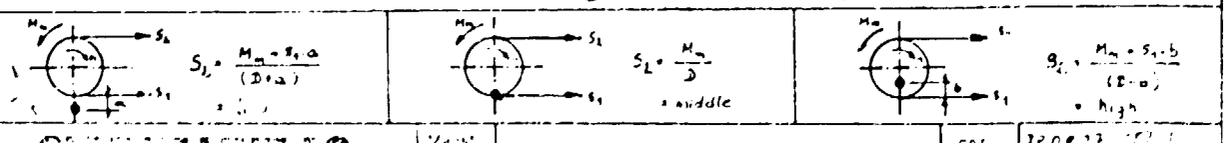
BELTING :

cover material : Polyamid
tie rod : single polyamid strips to join closely to pulley camber. High tensile strenght.
tread : chromium leather with high coefficient of friction (~0,6)



NOTICE ! :

- By changing the engine you have to make sure of right rotation, same weight and size of engine and limitation of whip movement (danger of belt damage!).
- polished cambered pulley
- short belt (otherwise weight tension !)



F I T T I N G S used by ATP

Medium : SULPHURIC ACID

producer	: Rheinhütte - Western Germany
type	: gate valve - AZ 1915
size	: DN 15o , Pn 6
material	: Nr. 4136, stuffing box-Nr.4410, TFE-asbestos packing.
speciality	: two-piece casing, seating parts easily to regrind exchangeable wear parts, no pressure on stuffing box if valve is closed, low pressure drop because of low turbulence.
use	: for circulation pump to absorber-98% / 12o°C.
working period	: several years

producer	: Tuflin
type	: process valve with TFE-sleeves
size	: DN 70
material	: ductil iron - fully TFE-lined.
speciality	: rotating plug in a TFE-sleeve which is locked in the body. Without stuffing box and lubrication, seals are not exposed in either open or closed position
use	: outlet of acid dilution - 72-76 % H_2SO_4.
working period	:

Medium : PHOSPHORIC ACID up to 8o °C
up to 55 %

producer	: Erhard
type	: diaphragm valve FD (rubber squeeze valve).
size	: DN 125 , Pn 10
material	: cast iron - rubber lined diaphragm - soft rubber
speciality	: without stuffing box, exchangeable rubber lining and diaphragm, lifting limitation.
use	: throttle valve in acid pipes.
working period	:

producer	: DÜrholdt
type	: tyre valve
size	: DN 50, PN 10
material	: cast-iron for casing with anticorrosive protection layer; resistant rubber tyre. (TFE - silvered rubber parts for sulphuric acid).
speciality	: without stuffing box, exchangeable rubber parts
use	: stop valve for phosphoric acid.
working period	:

Medium : NPK-SLURRY , y= 1,3 to 1,7 / 11o to 14o °C
bicalciumphosphate
ammoniumnitrate
calciumnitrate, -chloride and 20 % water

---

producer : Worcester
type : 4466 T ball valve
size : DN 1oo (25)
material : Nr. 4401 for body, ball and shaft.
TFE for sealings
speciality : no maintenance, no greasing.
exchangeable wear parts
use : Stop-valve for NPK-circulation.
working period : about 2 month.

---

producer : --- Chemie Linz designed.
type : ---
size : DN 3O
material : Nr. 4580
tube in Si-casting, TFE-sealing
speciality : exchangeable tube and disk
simple construction.
use : Throttle valve for NPK-slurry to sphärodizer.
working period : 3-month

---

producer : Tuflin
type : D 127 througway valve
size : DN5o
material : stainless steel for body (18-1o-Mo)
TFE for ring, sleeve and diaphragm.
speciality : no maintenance and lubrication
use : slurry circulation
working period : several weeks

---

producer : Gecos W-Germany
type : PR- plug valve
size : DN 1oo
material : tfe-sealing

speciality : no stuffing box
lubrication box for all time greasing.
use : slurry pipe to sphärodizer

OK APPROVED

DIFFERENT TYPES OF PUMPS used by ATP (1)

Medium : SULPHURIC ACID

CENTRIFUGAL PUMPS (horizontal)

Producer : Ochsner - Austria
type : U-MOR
capacity : 1oo m^3/h - 2o m (5o°C) 98%
material : Cr-casting (Ni-alloyed)
speciality: hydraulic shaft sealing; useable for high inlet pressure.
use : circulation pump - acid store.
function : hydraulic sealing by auxiliary impeller.
in operation no contact of shaft and stuffing box because of axial shaft movement.

working period : about 12 month (temporary working).

Producer : Rheinhütte - Western germany
type : RE 15o/265
capacity : 24o m^3/h - 2o m (up to 12o °C - 98 %)
material : Nr. 4136
speciality: Hydraulic sealing - impeller with backside vanes
use : circulation pump for absorbing tower
function : stillstand - double stuffing box and special ring valve
working - hydraulic sealing
working period : about 12 month (continuous working).

Producer : Rheinhütte - Western Germany
type : RE 3o/25o
capacity : 5o m^3/h - 2o m ; 6o°c ; 66-73 % .
material : 18% Si-casting
speciality: divided, removeable casing in steel casting-
wear resisten Si-parts for acid contact.
hydraulic sealing - impeller with backside vanes.
double stuffing box and special ring valve.
working period :

SUBMERSIBLE PUMPS (vertical)

Producer : Rheinhütte - Western Germany
type : GVS 15o/ 265
capacity : 113 m^3/h - 15m ; 1oo °C ; 98 %
material : Nr. 4136 , carbon shaft box.
speciality:
use : circulation pump - drying and absorbing tower.
working period : about 12 month (continuous working) .

Medium : LIQID SULPHUR

SUBMERSIBLE PUMPS

Producer : Rheinhütte - Western Germany
type : GVS 25/22o
capacity : 25 m^3/h - 45 m liqid sulphur, 135 °C
material : cast iron, steel shaft, shaft protection box Nr.4o34
speciality: steam heated casing (3,5 bar)
use : sulphur to furnace.
working period : about 12 (6) month (continuous working).

Medium : NPK - SLURRY 100 °C , spez. weight 1,5 - 1,7

CENTRIFUGAL PUMPS (sludge pumps with packing fluid)

Producer : Klein (Jeumont Schneider) - France
type : wd 100 G
capacity : 40 m³/h - 45 m , 1450 rpm
material : nr 4460 or G-X 10CrNiMo 27 5.
shaft : nr 4530 plate welding with Celsit 50Nb
speciality: special designed impeller
stuffing box with PTFE-packing and sealing liquid.
exchangeable wear disks and rings.
use : NPK-slurry to sphärodizer and circulation.
period of working : about 4 month (continuous working).

Producer : Worthington
type : 2 CNG 104
capacity : 30 m³/h- 6 bar , 1800 rpm
material : "Worthite" - 20Cr/25Ni+2,5Mo - nb stabilized and thermal treated.
shaft nr. 4586
speciality: variable split of impeller by movement of the casing cap.
use : NPK-slurry circulation.
period of working : about 4 month (continuous working).

Medium : PHOSPHORIC ACID
H_3PO_4-slurry - 30% P_2O_5 , 3% H_2SO_4 ,
60% liquid - 40% solid, 80 °C , y = 1,7

SUBMERSIBLE PUMPS (centrifugal, vertical)

Producer : Ochsner - Austria
type : MOVS - 38 / 200
capacity : 240 m³/h - 13,7 m 970 rpm
material : nr. 4500
speciality: exchangeable wear disks and rings

use : H_3PO_4-slurry to evaporation cooler
period of working : 2-5 month (continuous working)

Medium : PHOSPHORIC ACID
H_3PO_4 -slurry

SUBMERSIBLE PUMPS (centrifugal, vertical)

Producer : Ensival - Belgum
Type : 3o BAV B 8o
Capacity: : 41 m^3/h - 18 m , 145o rpm
material : nr. 45oo , nr. 4577
speciality: impeller with backside vanes
exchangeable wear disks and rings.
use : slurry to filter
working period : about 5 month (continuous working).

Medium : Washing Water (5 % H_2 Si F6; 2-3 % S1O
- Waste Gas Cleaming. γ = 1,05, t = 30 - 50 °C

Centrifugal Pump (horizontal)

Producer: Ochsner - Austria
Type : E-Mor 2213/50 H
Capacity: 25 m3/h - 45 m - 2800 rpm
Material: all parts with fluid contact - rubber lined,
shaft protectionring Nr. 4550
Speciality: hydraulic sealing (patent Mackensen)
Use : circulation pump for waste gas cleaner
Working period

ROLLER-ADJUSTMENT for ROTARY KILN or big ROTATING DRUM.

To keep the wear and tear of rollers, tyres and gearboxes of an inclined, rotating drum as low as possible you have to keep up a continuous movement in longitudinal axis- up and down. This axial movement should be limited by two horizontal rollers. The period of moving up and down (distance i.e. 60 mm) should be about 8 hours.

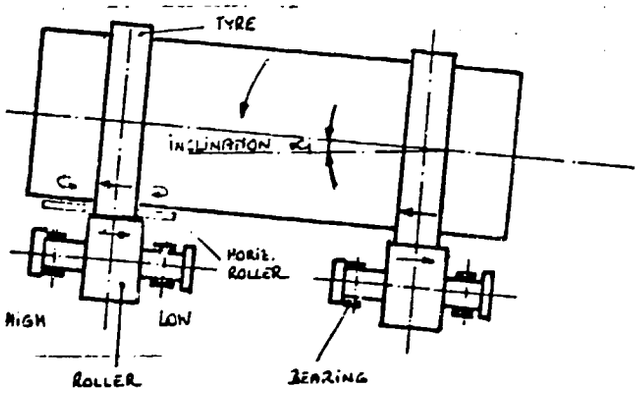
There are different possibilities to manage this movement:

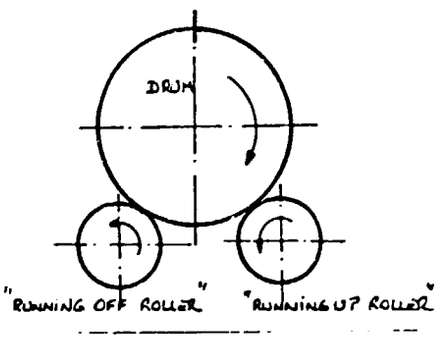
1. HYDRAULIC MOVEMENT

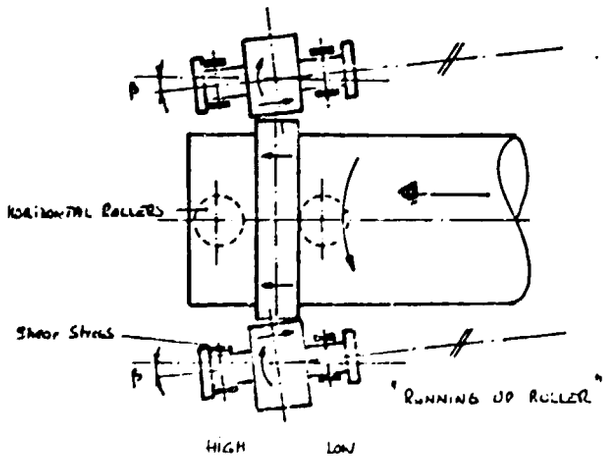
The kiln or drum slowly is pushed up and down by hydraulic cylinders in certain periods.

2. CROSSING OF THE ROLLERS

You start shifting the rollers at the station which is nearest to the impulsion or horizontal rollers and you continue downwards if necessary.
You always have to lift the "running up roller" on this side of the tyre where you intend the drum to move along. Don't lift too much and always keep the roller shafts of one station parallel otherwise abrasion would increase. You strictly have to control temperature of bearings (60 °C). If the drum is in position high and won't come down you have to lubricate the roller surfaces.







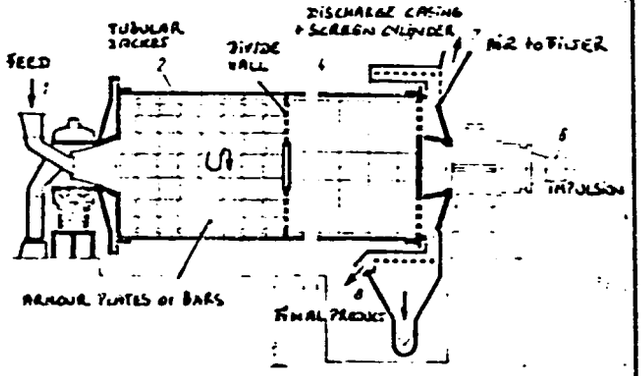
Data sheet [illegible] filled out by ACZ

G R I N D I N G

BALL MILL

lined with wear resistant Cr-Mn-Mo alloyed steel (1. 3401

Casted or forged balls up to a size of 100 mm Ø .



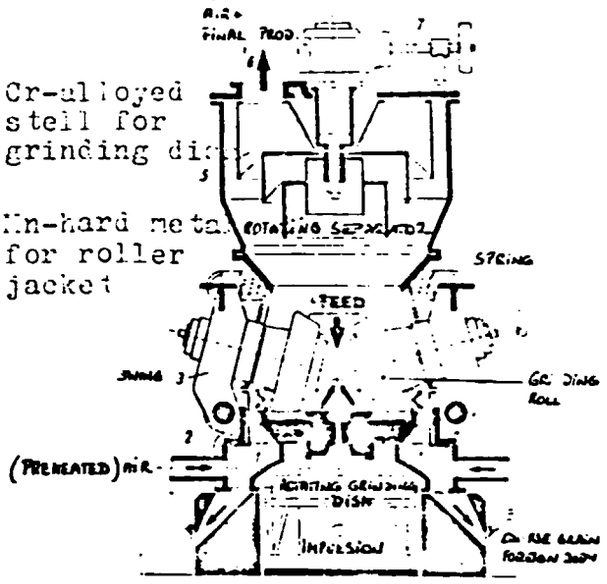
grinding stock: rock phosphate, coke cement clinker, sand

used as separator mill : phosphate, coke, sand
or through-way mill : cement clinker

ROLLER MILL

Cr-alloyed steel for grinding dis

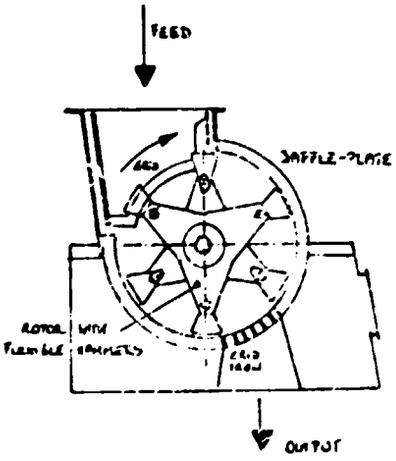
Mn-hard meta for roller jacket

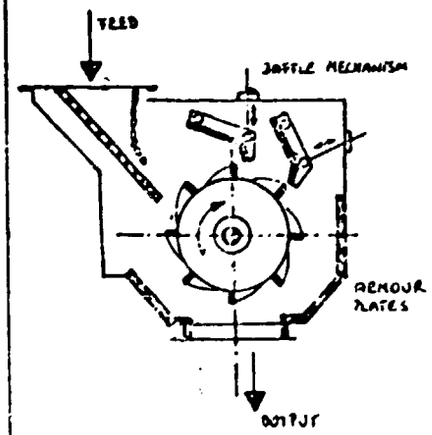


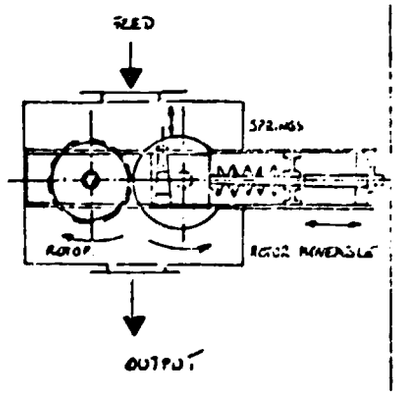
grinding stock: anhydrite, coke, drying of fly-ash.

C R U S H I N G

HAMMER CRUSHER			BAFFLE CRUSHER	ROLLING CRUSHER
grinding stock:		anhydrite	granulated HPK	granulated HPK
size:	input :	o-250 mm	25-150 mm	0-25 mm
	output:	o- 20 mm	o- 30 mm	o- 2 mm





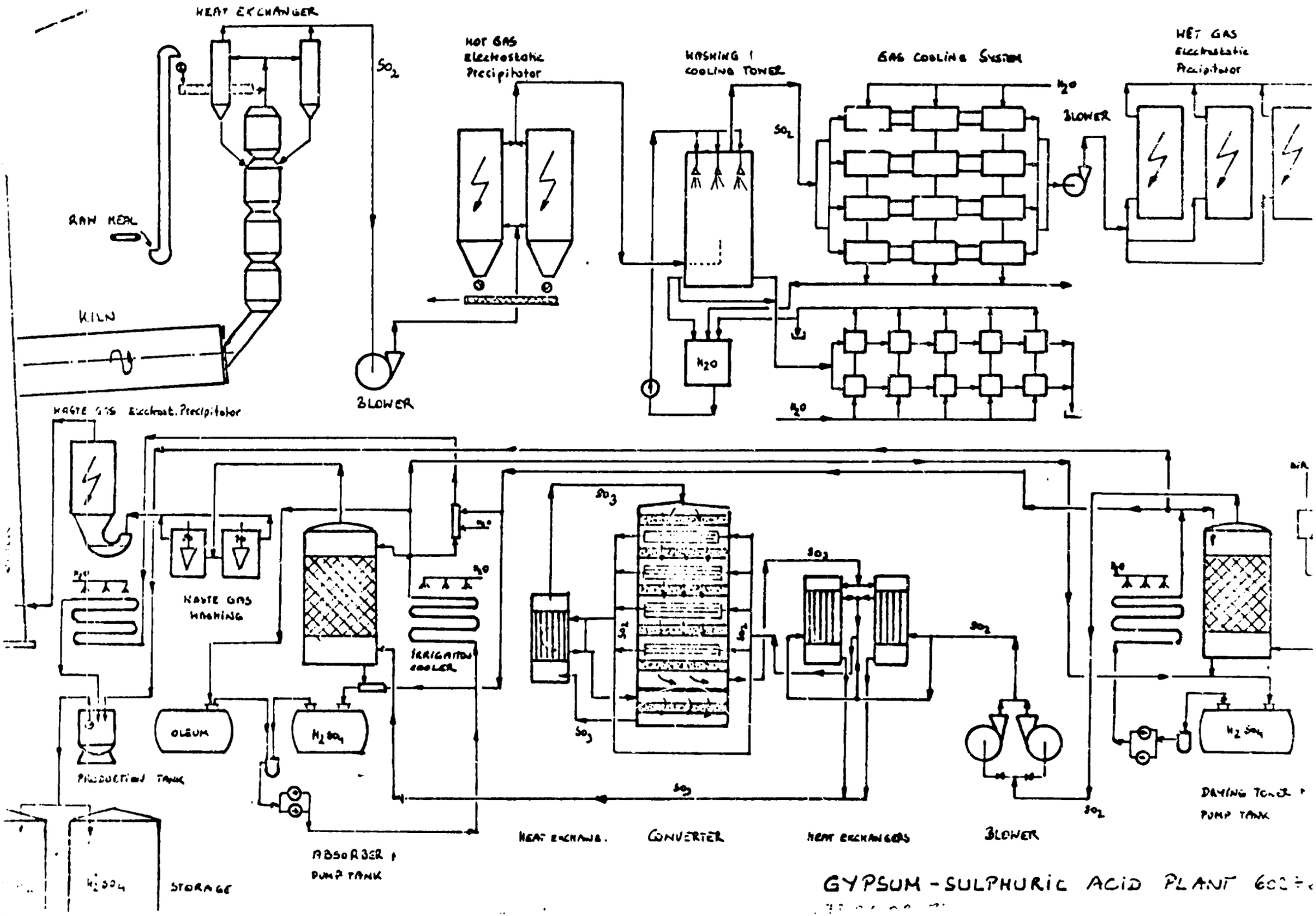


materials :

armour plates : Mn-steel

[illegible] : 3% 12% Mn12

rollers : Cr-Ni [illegible]



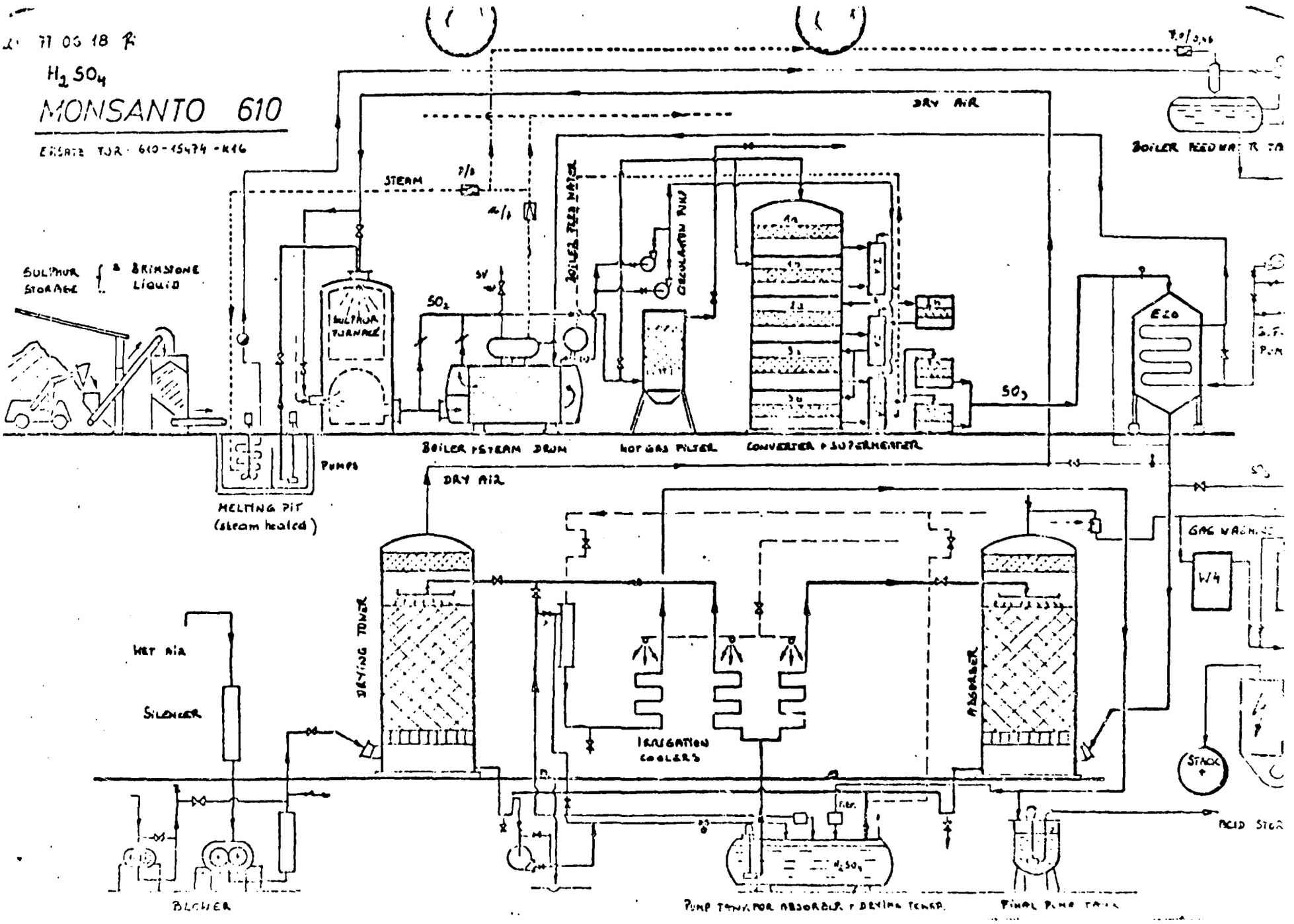
GYPSUM - SULPHURIC ACID PLANT 600 t

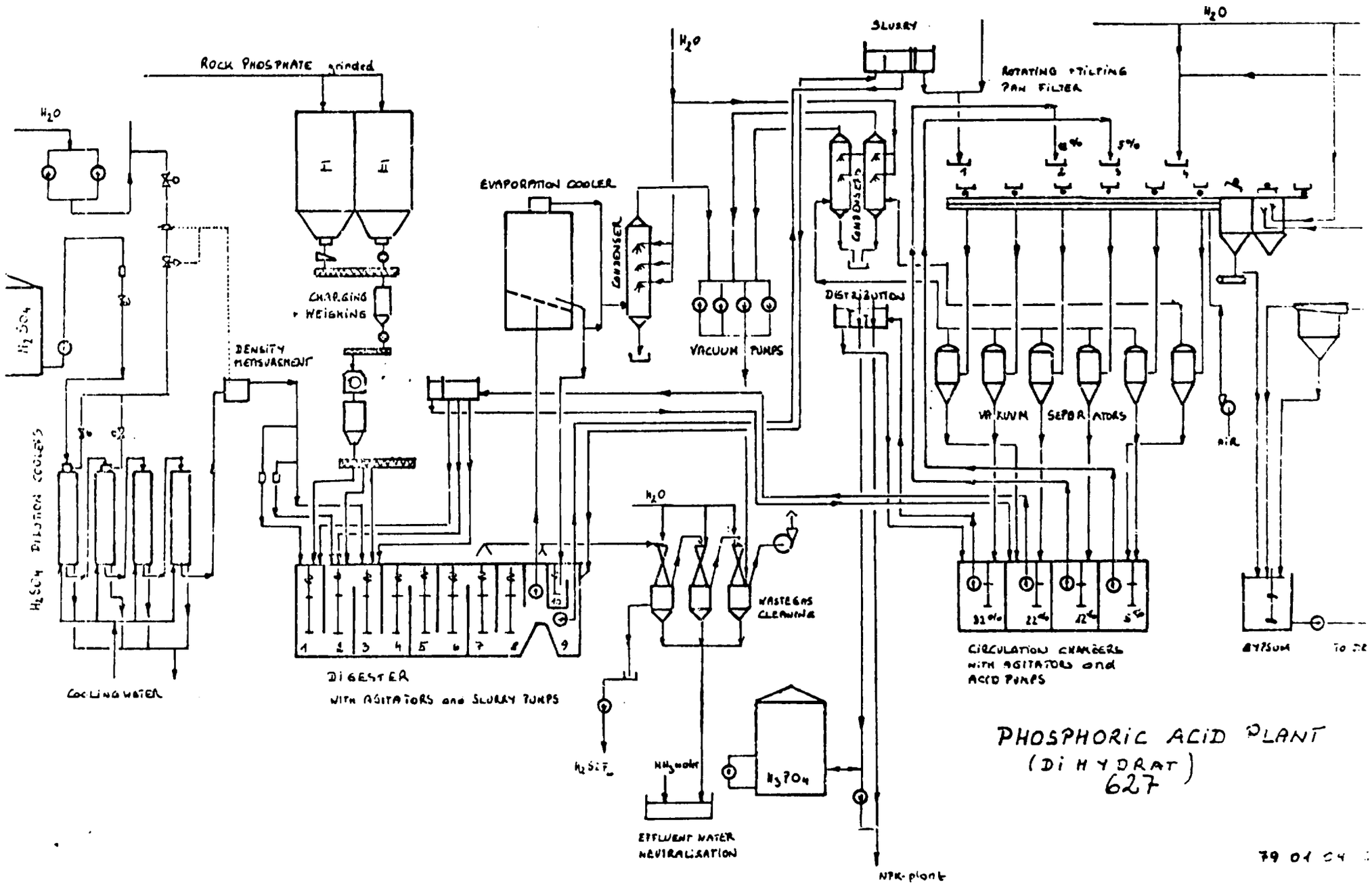
77 05 18 R

H_2SO_4

MONSANTO 610

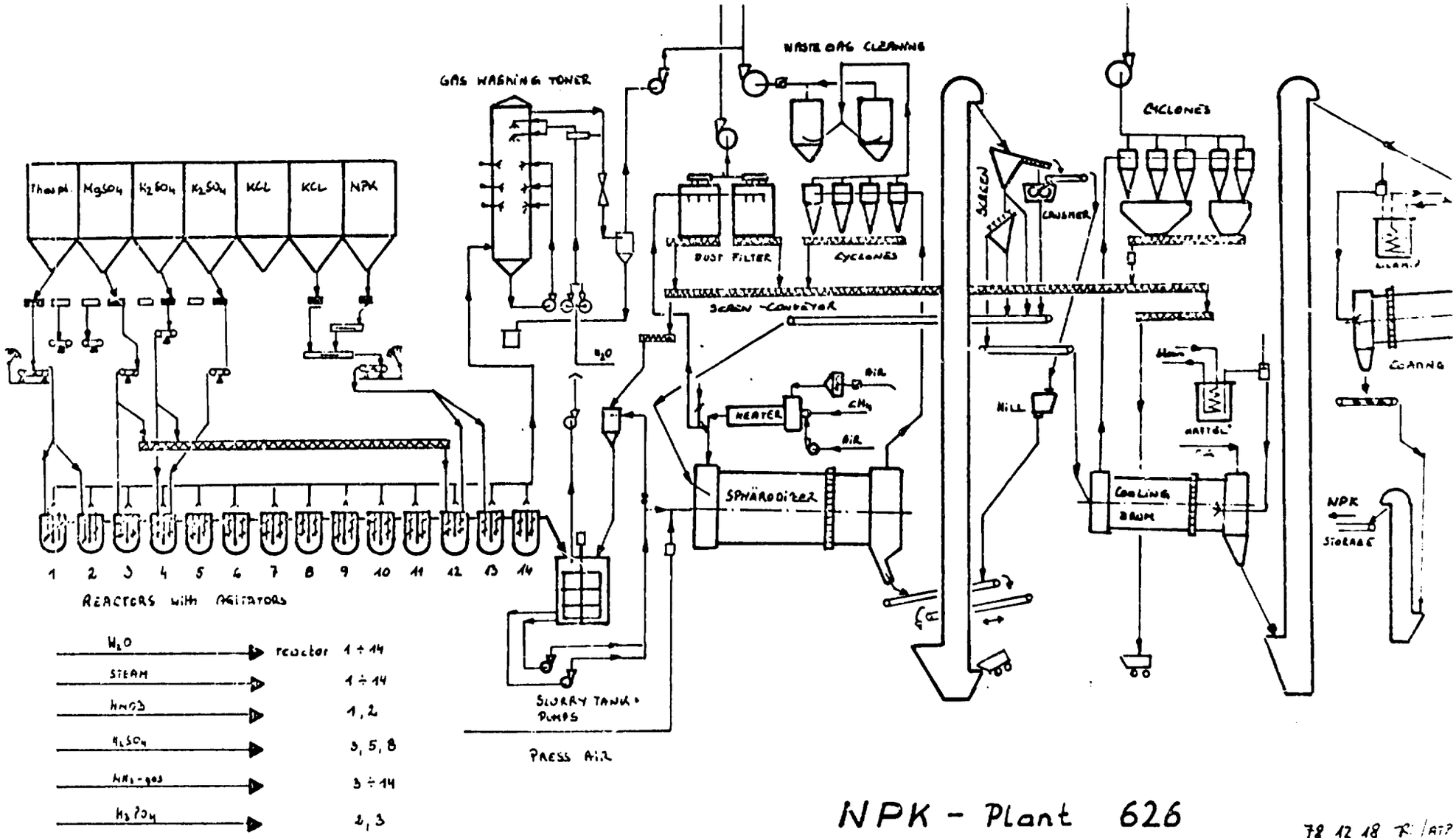
ERSATZ FÜR: 610-15474-R16





PHOSPHORIC ACID PLANT
(DI HYDRAT)
627

79 01 04

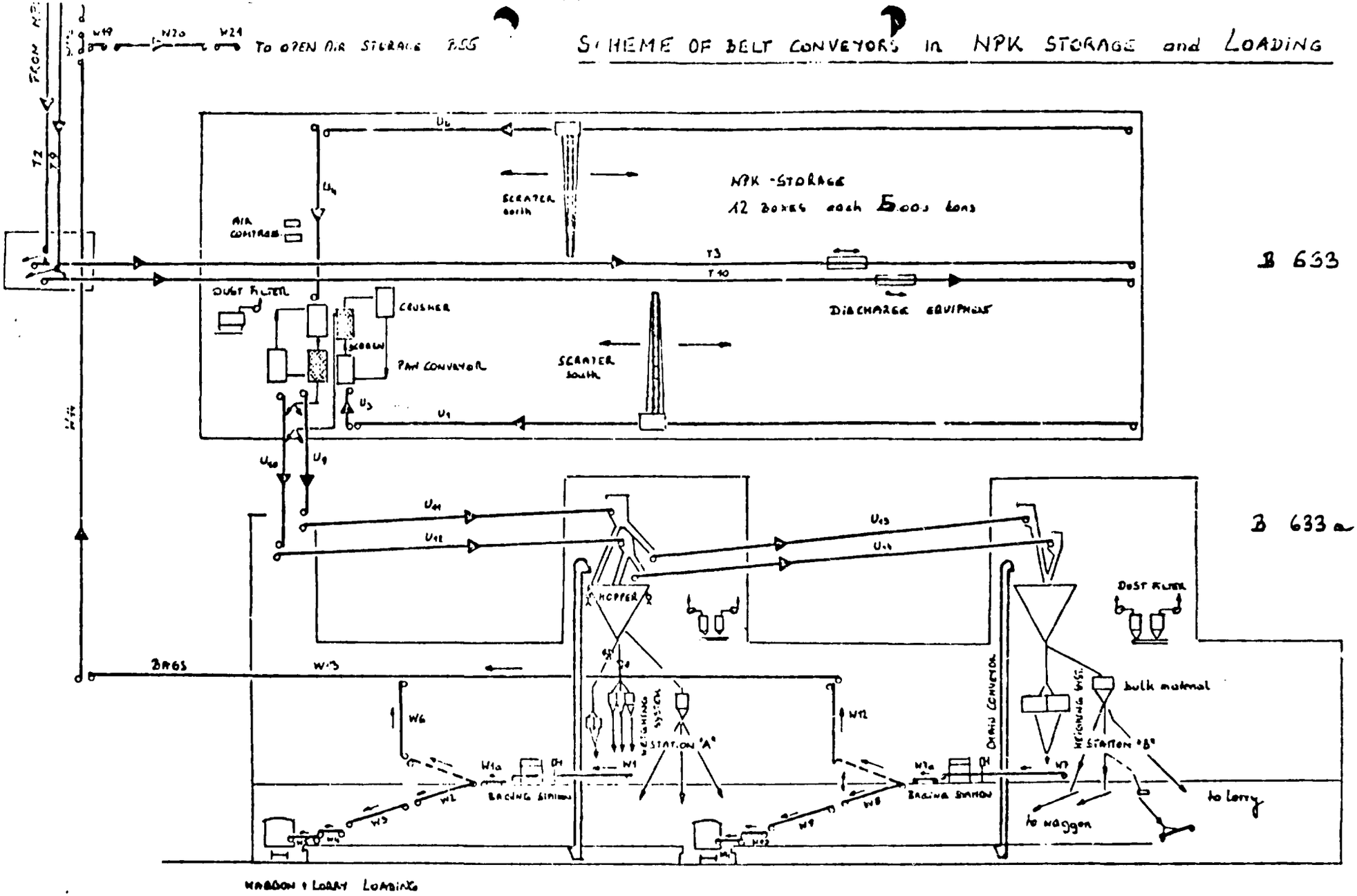


NPK - Plant 626

(2 DIGESTION-SYSTEMS + 3 SPHÄRODIZERS)

78 12 18 K/AT?

SCHEME OF BELT CONVEYORS IN NPK STORAGE and LOADING



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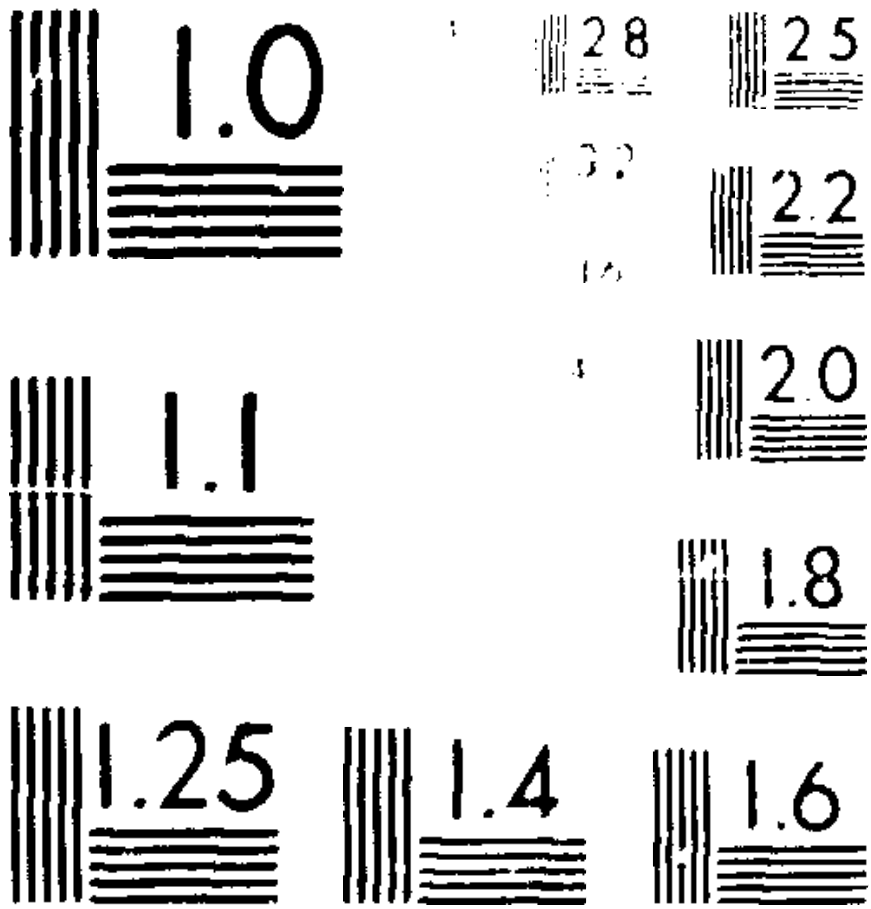
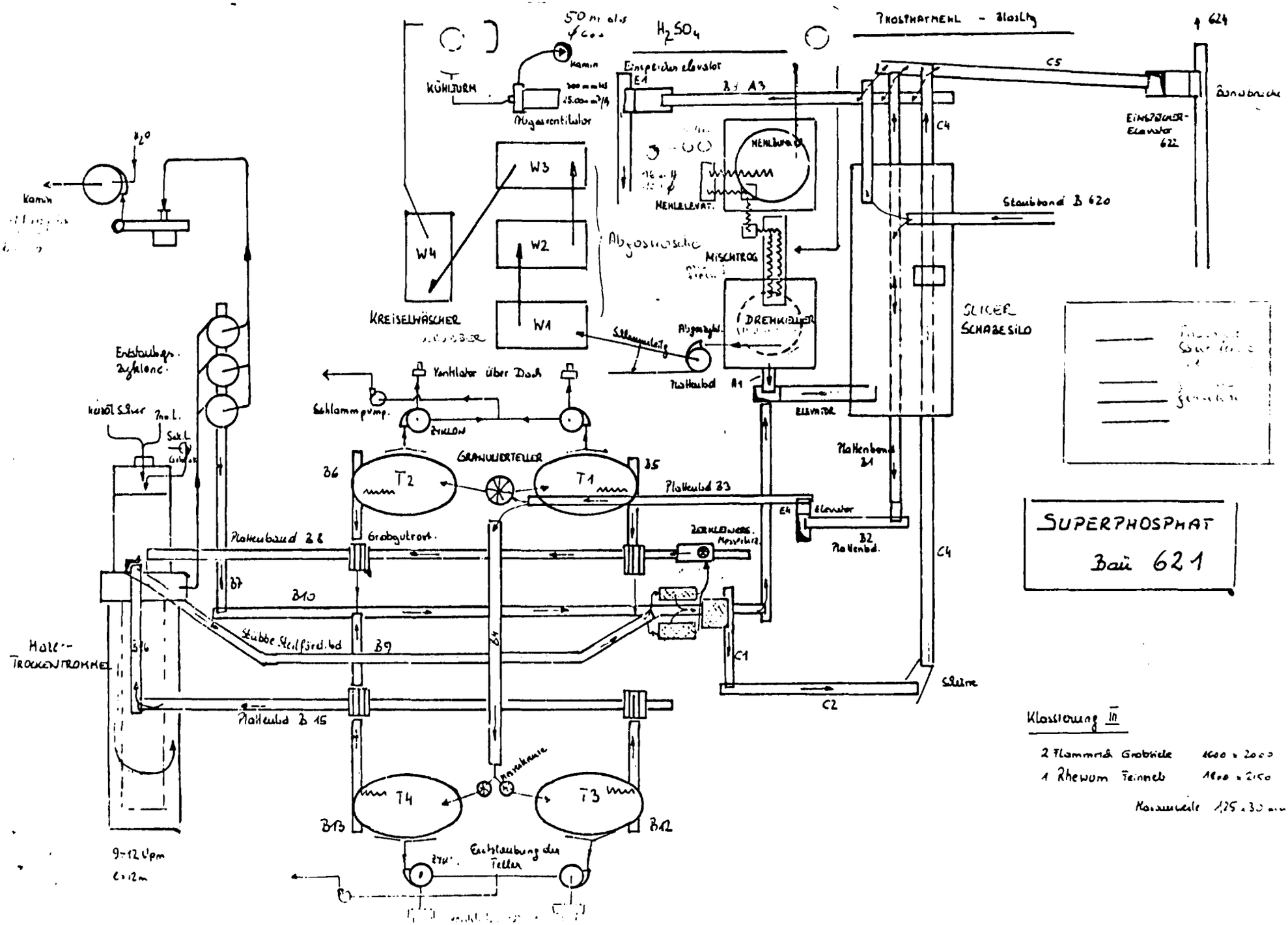

1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6



SUPERPHOSPHAT

Bau 621

4. UNIDO-Workshop

Maintenance Problems of the Urea Plant

The major problem in an urea plant is the sealing of the high pressure section. It is of vital importance that the surfaces and the lense are very clean. The lense hardness must be less than the hardness of the piping.
The gasket of the reactor manhole is an aluminium-teflon tape gasket.

A second point are the high pressure pumps. We use pumps designed and fabricated by Worthington (Hamburg). After 1 1/2 year of service we can say that they work satisfactory.
The piston packing lasts about one year.
The valves have to be changed about every six month.

The packing (details give the attacked drawings) has to be prepressed.
Valves fail mainly because of spring breaks.
This can be influenced by the spring material and the spring geometry.
The CO_2-compressor - which is maintained by ATH - had problems mainly because of vibrations.

Material problems existed mainly during the start-up-phase. The welds of the reactor lining had to be repaired (lining material is 316L).

./2

Until now the large width belts in the prilling-tower are not satisfacotry. We have to change them after about 1 1/2 year, which is a too short time of service. We plan to substitute these synthetic belts by rubber belts.

In the urea storage the main problem was the sack-welding-machine. This was mainly a problem of adjusting the welding temperature and the lenght of the cooling zone on the sack-welding-machine.

O R G A N I S A T I O N [illegible]

Maintenance Group for [illegible]

Department Manager [illegible]

(Dr. [illegible])

Deputy Manager (Dr. [illegible])

Chief Master (Mr. [illegible])

Master (Mr. [illegible])

Fitters (Mr. [illegible], Mr. [illegible])

Craftsmen

Mr. [illegible] Mr. [illegible] Mr. [illegible] Mr. [illegible]

[illegible] [illegible] [illegible] [illegible]

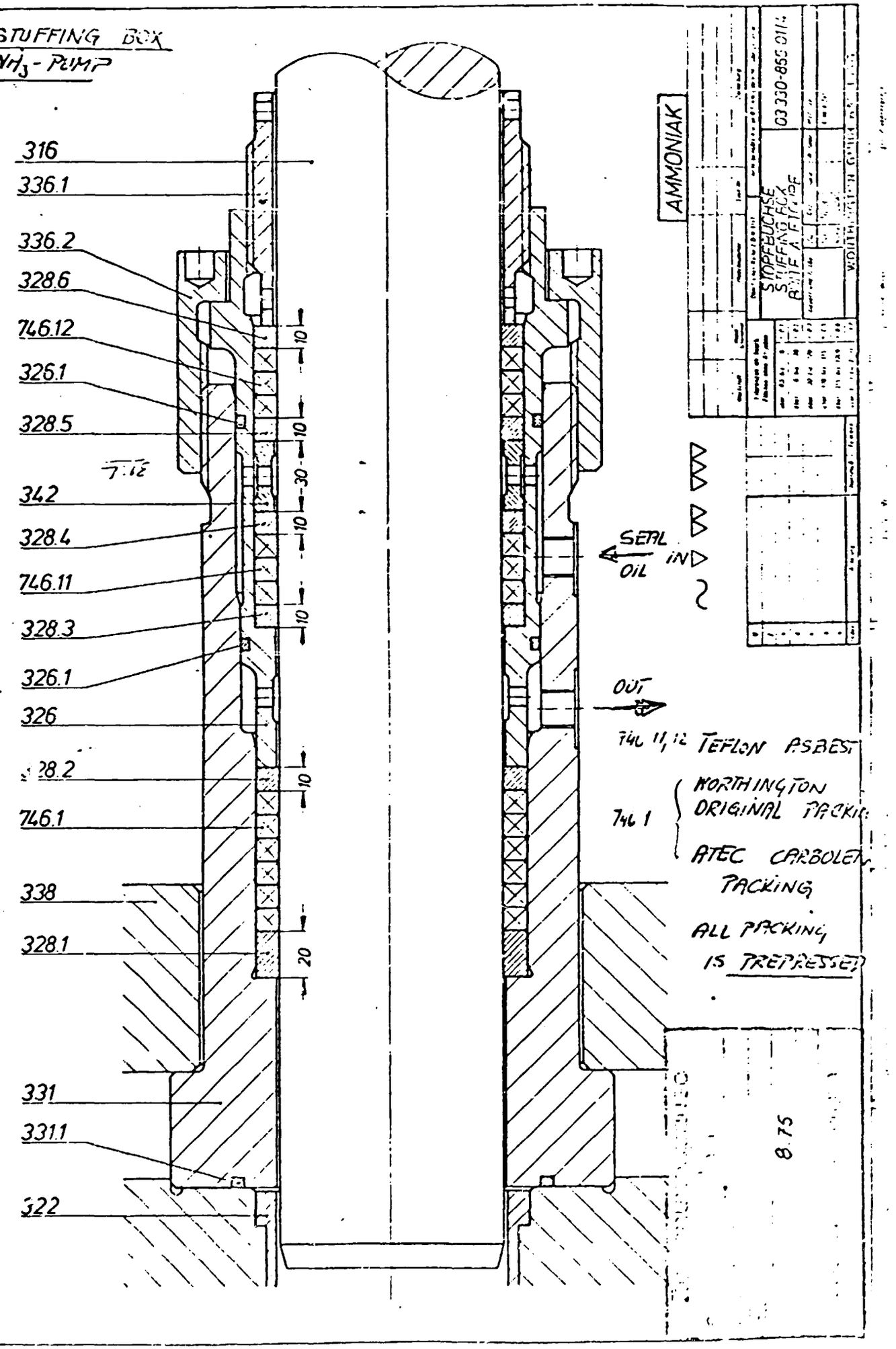
U R E A P L A N T

Our new urea plant was built in 1975/1976 and substitutes an old 300 m ton/day plant.
The start up was early 1977. The design capacity is 1000 m ton/day. It is a SNAM PROGETTI PROCESS. After overcoming various start up problems, we can say that the performance of the plant is good. Since 1978 we reached an on-stream factor of 330 days per year.

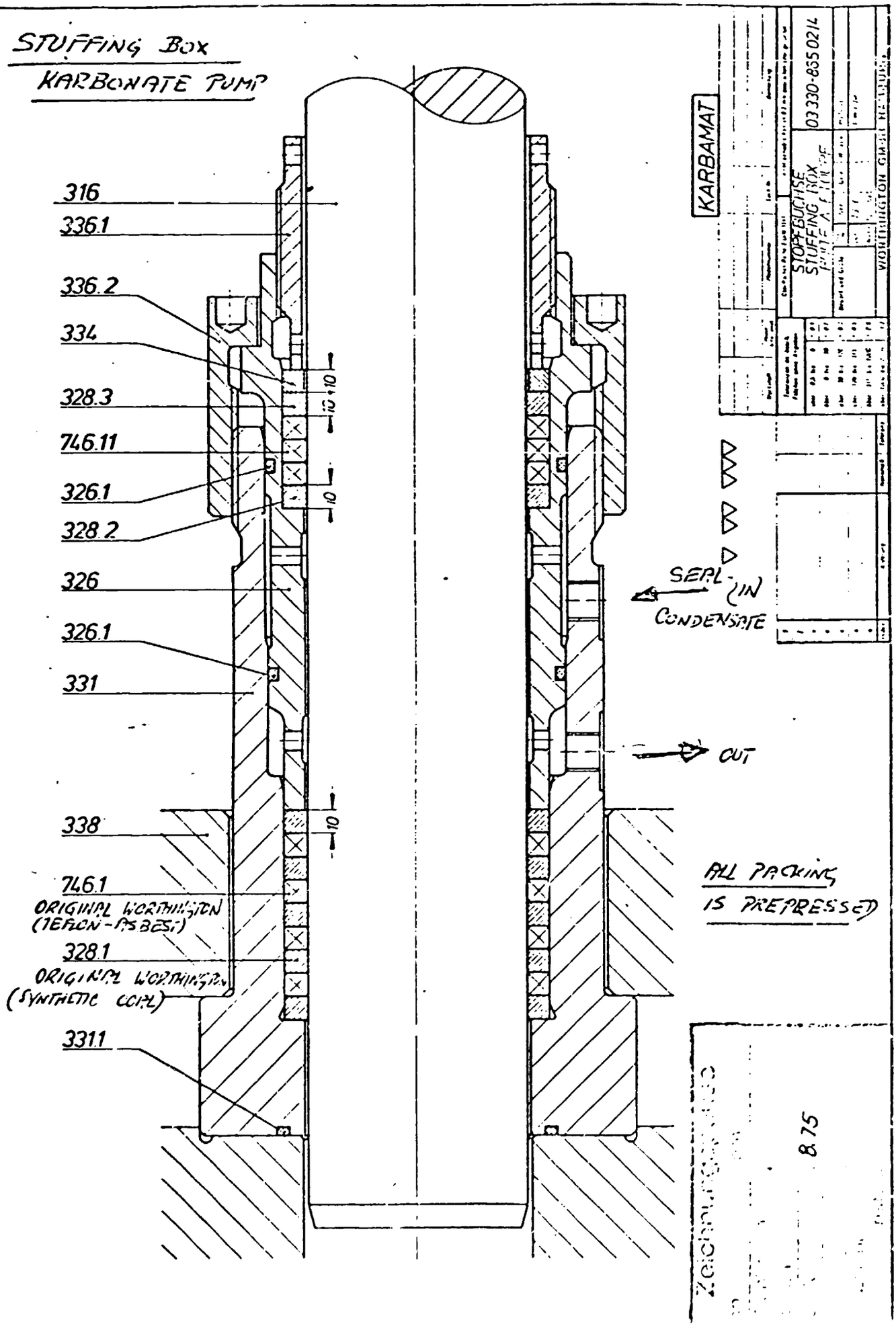
Mayor equipement and its vendors:

equipement	vendor
CO_2-Compressor (5 Stage reciprocating compressor)	GHH (BRD)
NH_3-Pumps 7 Plunger pump	Worthington (BRD)
Carbonat Pumps 5 Plunger pump	Worthington (BRD)
Ejector, Vacuum System	Koerting (BRD)
Reactor	VOEST ALPINE (A)
Carbamate separator	" " "
Stripper	FBM Milano (I)
Centrifugal pumps	Ochsner Linz (A)
Belt Conveyor System	Mut Stockerau (A)
Scrapper	Schade BRD)
Weighing System Sack Welding Machine	Libra BRD)

STUFFING BOX
NH_3 - PUMP



STUFFING BOX
KARBONATE PUMP



4. UNIDO-Workshop

Activities, Duties and Organization of the Civil Department

The main task of the civil department are:

- Planning of civil constructions of small and large projects
- Maintenance of buildings, streets, steel constructions, sewers, railway tracks etc.
- Administration of all documents, static calculations and plans concerning civil activities. Contact with public authorities concerning questions of public or CHEMIE LINZ interests.

Planning and administration are done by the planning group which is divided in 5 subdivisions.

- industrial plants construction and statics
- building-, storage- and pharmaceutical plants construction
- steel constructions
- sewers, streets, railway tracks and surveying
- water installations, heating and ventilation, insulation of air condition equipment

The planning group consists of about 30 staff members. Up to the sum of 200 million Schillings (about 15 million Dollars) of erection costs a year, this group is able to do the whole work alone. If there are some extensive projects at the same time, outside planning bureaus support the planning group.

Supervision and repairing are done by the supervision group. On the one hand the 15 members of the supervision group have to supervise the erection and repairing done by outside con-

./2

tractors, and on the other hand they have to direct the 7 repairing groups:

- bricklayers, floor tilers and roofers (20 men)
- special bricklayers (refractory brickwork, acid- and lye resistant brickwork), coating (20 men)
- sewermen (20 men)
- carpenters and scaffold carpenters (20 men)
- painters (houses and steel constructions) (20 men)
- insulating group (pipes, boilers, furnaces etc.) (20 men)
- railway track repairing group (10 men)

Every group is led by a forman and an assistant forman. Some five workers, bricklayers scaffold carpenters and insulating workers are within reach day and night for emergency in production plants. During the winter track workers are also within reach, because the switches can be blocked by snow and ice.

To give a picture of the work that has to be done by these 150 men it is necessary to know some data about the CHEMIE LINZ plant in Linz.
The plant area is about 1,5 km^2.
Some 350 buildings and other constructions of civil character stand there. Approximately 120 000 m^2 of roofs are to be kept in good condition. A special problem is the coating of the countless steel constructions, pipes and boilers in an aggressive atmosphere. About 15 km of streets, 15 km main sewers and 35 km railway tracks with some 120 switches are to be repaired continuously.

About 100 million Schillings (7 million Dollars) are spent for maintenance every year. One half of the work is done by the CHEMIE LINZ repairing team, the other one is done by outside contractors.

./3

The repairing group is kept as small as possible. The number of the workers is just as high as it must be, allowing the group to do:

- all emergency jobs in a quick way, even during night and weekend
- all jobs that are too small in scope or too difficult to survey for outside contractors.
- all jobs that need special workers or special knowledge of the units.

The main jobs given to outside contractors are:

- roofing of large roofs
- coating of steel contructions
- housepainting
- repairing of streets and railway tracks.

Translation - aid

HS 34 ...
HS 45 ...

Tradenames of PUR-foam for insulating purposes (esp. cold insulation), available at Chemie Linz (See adress at the end of the page.

HS 34 or HS 45 is one component of a 2-component system for producing a hard foam (unit-weight 20 - 30 kg/m3, free foaming).

Because of its slow reaction it is especially good for hand-made foams andfor great vo.uminas.

US 23 Teil 2 is the second component.

Componding ratio 1 : 1

Processing charakteristics

	manuel		with HD-machine	
	HS 45	HS 34	HS 45	HS 34
starting time sec.	40 ± 5	60 - 90	12 ± 2	25 ± 5
setting time sec.	120 ± 10	300 - 450	50 ± 5	160 ± 20
growing time min.	ca. 3	ca. 6-10	ca.1-2	ca. 5

Mould release properties

30 mm thick sheets can be released after 10 min (HS 45) or 20 min (HS 34) in a 35°C metal mould (density 0,06 g/cm^3, mould foaming).

Dimensional stability

Total stability from - 20°C up to 120°C. Less than 3 % volumia growing (24 hours).

Coefficient of thermal conductivity

At a density of 0,03 g/m^3 thermal conductivity is 0,02 W/km.

Water immersion

Less than 1,5 %.

Storing stability

6 month

Spezially used for

Different insulations, e.g. cooling boxes, boats, technical insulations, foaming of holes.

For more information ask CHEMIE LINZ AG.

4. UNIDO-Workshop

1. Balancing

1.1. Introduction

Unbalanced centrifugal forces and momentums are not wanted for:

- high dynamic bearingforces → reduce of useful life
- Vibrations → fatigue-breackings
- Reduction of friction
- Reduction the value of produce (employment)
- Noisy machines
- Influence to personal

Balancing is the process of attempting to improve the mass distribution of a body so that it rotates in its bearings without unbalanced centrifugal forces.

1.2. Measuring of Unbalance:

Unbalance is a vetor therefor the amount and the angle of unbalance must be measured.

1.2.1. Centrifugal Balancing Machines: (a balancing machine that provides for the support and rotation of a rotor and for the measurement of once per revolution vibratory forces of motions due to unbalance in the rotor)

a) Soft Bearing (above resonance) balancing machine (having an operating speed above the natural frequency of the suspension-and-rotor system)

- Resonance Balancing Machine: a balancing machine having an operating speed at the natural frequency of the suspension-and-rotor system.
- Compensating (null force) Balancing Machine: a balancing machine with a built-in calibrated force system with counteracts the unbalanced forces in the rotor.

./2

- Direct Reading Balancing Machine: a balancing machine which indicates the unbalance directly.

b) Hard Bearing (below resonance) Balancing Machine: a balancing machine having an operating speed below the natural frequency of the suspension and rotor system. It is to use dynamometer and to use very rigid foundation and construction of the machine.

c) Field Balancing: The process of balancing a rotor in its own bearings and supporting structure which full rotation. Measure are given with field balancing equipment.

Under such conditions the information required to perform balancing is derived from measurements of vibratory forces or motions of the supporting structure and/or measurements of other responses to rotor unbalance.

1.2.2. Indicating Systems:

- Wattmetric indicating system
- Voltmetric indicating system with phase-sensitive rectifier
- Voltmetric system with stroboscope and filter
- Voltmetric indicating system with marking of ungular position on the rotor itself
- Compensator with mechanical or electric indication

1.2.3. Motion Transducer:

- Piezzo-motion transducer: measure voltage is proportional of the acceleration
- Electrodynamic-motion transducer: measure voltage is proportional of the velocity
- Inductiv-motion transducer: measure voltage is proportional of the displacement

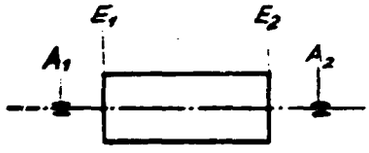
./3

1.3. Balancing Proceeding

1.3.1. Static Balancing (is a condition of unbalance for which the central principal axis is displaced only parallel to the shaft axis)

For disk-shaped rotors the use of only one correction plane may be sufficient, provided the bearing distance is sufficiently large and the disk rotates with sufficiently small axial run-out. Single plane balancing can be done on a pair of knife edges without rotation of the rotor (Gravitational (non rotating) balancing machine) but is now more usually done on centrifugal balancing machines.

1.3.2. Dynamic Balancing (is a condition in which the central principal axis is not coincident with the shaft axis)



$E_{1,2}$ ... Correction plane

$A_{1,2}$ ... Measuring plane

1. Run: Is a run with the original unbalance. Measuring the vectors

$\overrightarrow{V_{1,0}}$ and $\overrightarrow{V_{2,0}}$.

2. Run: A known trial mass (m_1) is mounted in plane E_1. Measuring the vectors $\overrightarrow{V_{1,1}}$ and $\overrightarrow{V_{2,1}}$. Remove the trial mass and note the position with 0°.

3. Run: A known trial mass (m_2) is mounted in plan E_2. Measuring the vectors $\overrightarrow{V_{1,2}}$ and $\overrightarrow{V_{2,2}}$. Remove the trial mass and note the position with 0° too.

Evaluation:

- Graphic evaluation: it's used rare because it's protraced and fallible.

- Numerical evaluation: equations see at "Static and Dynamic Balancing". It's calculated by programable calculating machine in the best way.

1.4. Balance Quality of Rotating Rigid Bodies

Even after balancing, the rotor will possess residual unbalance. By means of the measuring equipment avilable today unbalance may now be reducded to rather low limits. However, it would be uneconomical to exaggerate the quality requirements. To what extent the untalance must be reduced, and where the optimal economic and technical compromise on balance quality has to be struck, can, in individual cases, be correctly determined only by extensiv measurement in the laboratory or in the field.
General we can say:

The residual unbalance force: $F = m.r.w^2$ m ... unbalance mass

Acceptability limit: $F = G/10$ G ... rotor weight

it follows: $\boxed{m \approx 10 \cdot \frac{G}{r.n^2}}$ m(kg); G(N); r(m); n (min^{-1})

For example: G = 100 kg
r = 100 mm
n = 6000 min^{-1}

$m \approx 10 \cdot \frac{1000}{0,1.6000^2} \approx 3.10^{-3}$ kg = 3 g

Terms of reference are given by VDI 2060:

On the basis of section 1.4. balance quality grades have been established which permit classification of the quality requirements. Each quality grade Q comprises a range of permissiable residual unbalances (e.w). See figure 1.
The quality grade Q equivalent to the centre of gravity-velocity.
The centre of gravity-displacement are given by:

$$e = \frac{Q}{w} \qquad Q\ (mm/s);\ w\ (s^{-1});\ e\ (mm)$$

The permissible residual unbalance:

$$\boxed{m = \frac{e.G}{r}} \qquad m\ (g);\ e\ (mm);\ G\ (kg),\ r\ (m)$$

./5

For example: G = 100 kg
r = 100 mm
n = 6000 min^{-1}
Q = 2,5

e = 0,04 mm
m = 4 g

In general, for rigit rotors with two correction planes, one-half of the recommended residual unbalance is to be taken for each plane. For disk-shaped rotors the full recommended valus holds for one plane.

2. Measuring Vibration

2.1. Introduction

High vibration are not wanted at the arguments like 1.1.

2.2. Hints for Measuring

It's possible to measure displacement, velecity or acceleration. For evaluate

$$(s;\ v = \frac{ds}{dt}\ ;\ a = \frac{d^2s}{dt^2})$$

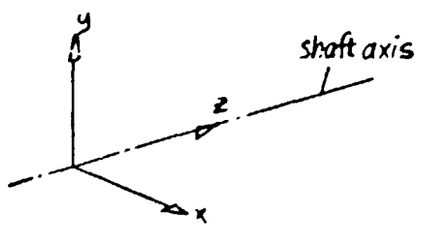
the vibration it's best to measure the rms-value of vibration velocity v_{rms}.

$$V_{rms} = \sqrt[2]{\frac{1}{T}\int_0^T V^2(t)\,dt}$$

The vibration severity of a machine is to be measured at operational speed. For variable-speed machines the measurements should be made at many speeds in order to locate the resonance frequencies which may possibly occur.

The machine support may significantly affect the vibration levels measured on the machine. During testing the machine should be either mounted on its operational foundation or - in case it is a small assembly - soft mounted respr. suspended on springs.

Test should be made preferably in x, y, z directions (choose the bearings of the machine)



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2.3. Evaluation Standards:

Comparing the measured values with the limit values specified in the Recommendations, will permit an eastimation of the severity of vibration to be carried out readily.

A machine may be qualified according to the examples of Quality Judgement (see "Vibration Signature Analysis-Techniques and Instrument Systems"). At first the tested machine has to be classified according to one of the six specified machine classes, Subsequently the limit values for the quality groups "good", "allowable", "just tolerable" and "not permissible", can be taken from the appropriate table. By comparing the measured vibration severity with these limit values an easy evaluation of the vibratory state can be made. Up to now, Examples of Quality Judgement have been established by the International Standard Organisation VDI 2056 for the Machine Classes K to T. The machine in Classes D and S vary considerably in their vibration characteristics and for this reason a classification in the same manner as with the first four classes has not yet been possible. For further explanations refer to the detailed discription of the proposed VDI 2056, ISO 2372, BS 4675.

Specifying of Machine Classes

Class K: Individual parts of engines and machines, integrally connected with the complete machine in its normal operating condition (production electrical motors of up to 15 kW are typical examples of machines in this category)

Class M: Medium-sized machines (typically electrical motors with 17 to 75 kW output) without special foundations; rigidly mounted engines or machines (up to 300 kW) on special foundations.

Class G: Large prime movers and other larger machines with rotating mass mounted in rigid and heavy foundations which are relatively stiff in the direction of vibration measurement.

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Class T: Large prime movers and other large machines with rotating mass mounted on foundations which are relatively soft in the direction of vibration measurement (for example, turbogenerator sets, especially those with lightweight substructures)

Class D: Machines and mechanical drive systems with unbalanceable inertia effects (say, due to reciprocating parts), mounted on foundations which are relatively stiff in the direction of vibration measurement.

Class S: Machines and mechanical drive systems with unbalanceable inertia effects (say, due to reciprocating parts), mounted on foundations, which are relatively soft in the direction of vibration measurement; machines with rotating slack-coupled masses such as beater shafts in grinding mills; machines, like centrifugal machines, with varying unbalances capable of operating as self-contained units without connecting components; vibrating screen, dynamic fatique-testing machines and vibration-exciter used in processing plants.

Balance quality grade G	e_{ω} 1) 2) mm/s	Rotor types — General examples
G 4 000	4 000	Crankshaft-drives 3) of rigidly mounted slow marine diesel engines with uneven number of cylinders 4)
G 1 600	1 600	Crankshaft-drives of rigidly mounted large two-cycle engines
G 630	630	Crankshaft-drives of rigidly mounted large four-cycle engines Crankshaft-drives of elastically mounted marine diesel engines
G 250	250	Crankshaft-drives of rigidly mounted fast four-cylinder diesel engines 4)
G 100	100	Crankshaft-drives of fast diesel engines with six or more cylinders 4) Complete engines (gasoline or diesel) for cars, trucks and locomotives 5)
G 40	40	Car wheels, wheel rims, wheel sets, drive shafts Crankshaft-drives of elastically mounted fast four-cycle engines (gasoline or diesel) with six or more cylinders 4) Crankshaft-drives for engines of cars, trucks and locomotives
G 16	16	Drive shafts (propeller shafts, cardan shafts) with special requirements Parts of crushing machinery — Parts of agricultural machinery Individual components of engines (gasoline or diesel) for cars, trucks and locomotives Crankshaft-drives of engines with six or more cylinders under special requirements
G 6,3	6,3	Parts of process plant machines — Marine main turbine gears (merchant service) Centrifuge drums — Fans — Assembled aircraft gas turbine rotors — Fly wheels Pump impellers - Machine-tool and general machinery parts Normal electrical armatures Individual components of engines under special requirements
G 2,5	2,5	Gas and steam turbines, including marine main turbines (merchant service) Rigid turbo-generator rotors — Rotors — Turbo-compressors Machine-tool drives Medium and large electrical armatures with special requirements Small electrical armatures — Turbine-driven pumps
G 1	1	Tape recorder and phonograph (gramophone) drives Grinding-machine drives Small electrical armatures with special requirements
G 0,4	0,4	Spindles, disks, and armatures of precision grinders Gyroscopes

1) $\omega = 2\pi n/60 \approx n/10$, if n is measured in revolutions per minute and ω in radians per second.
2) In general, for rigid rotors with two correction planes, one-half of the recommended residual unbalance is to be taken for each plane; these values apply usually for any two arbitrarily chosen planes, but the state of unbalance may be improved upon at the bearings. (See 3.2 and 3.4.) For disk-shaped rotors the full recommended value holds for one plane (see section 3).
3) A crankshaft-drive is an assembly which includes the crankshaft, a flywheel, clutch, pulley, vibration damper, rotating portion of connecting rod, etc. (see 3.5).
4) For the purposes of this International Standard, slow diesel engines are those with a piston velocity of less than 9 m/s; fast diesel engines are those with a piston velocity of greater than 9 m/s.
5) In complete engines, the rotor mass comprises the sum of all masses belonging to the crankshaft-drive described in Note 3 above.

Bild 3.25. TABLE of ISO Standard 1940 : Balance quality grades for various groups of representative rigid rotors.

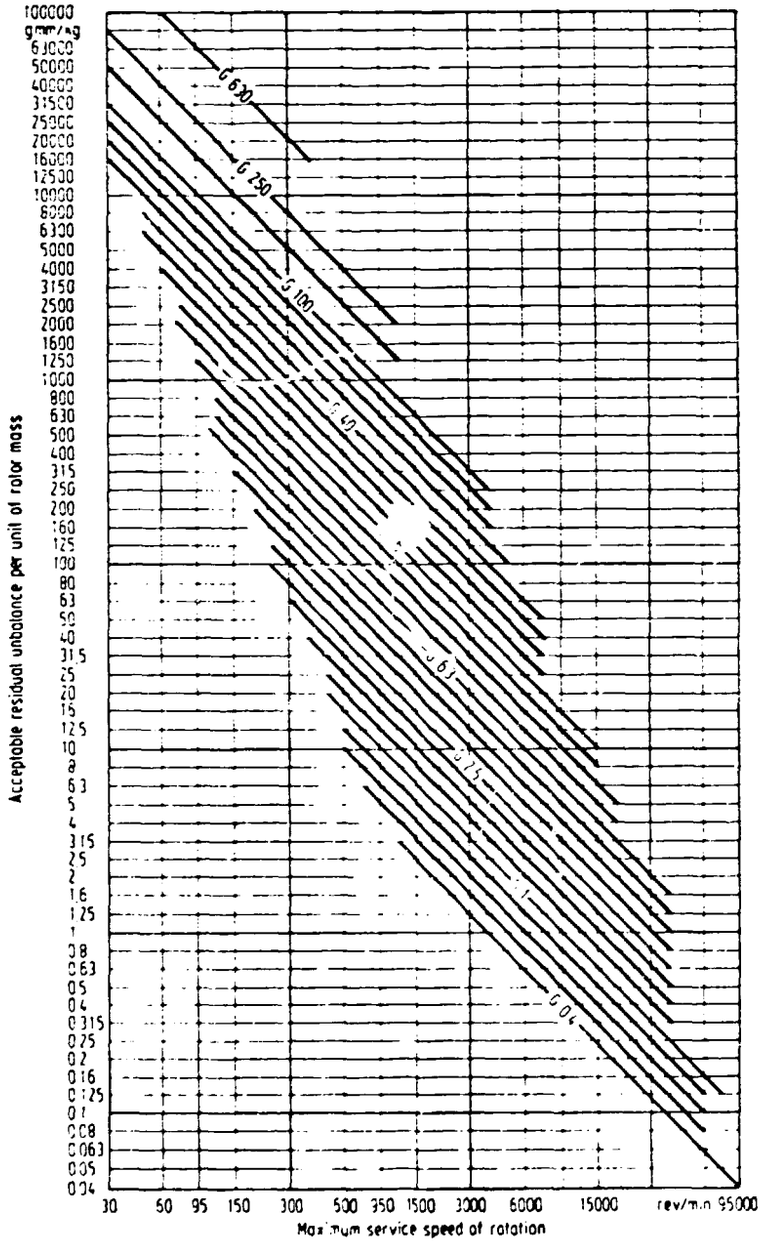

Bild 3.23. FIGURE 4 of ISO Standard 1940 : Maximum residual specific unbalance corresponding to various balance quality grades, G.

Static and Dynamic Balancing

by *John Vaughan*

Introduction

This note describes how measurements obtained with simple vibration instrumentation can be used when rotating machinery is to be balanced. Several straight forward methods of balancing will be presented that make use of portable B & K Vibration Meters to measure on rotating parts running in their own bearings at normal operating speeds. The various methods will be explained by means of worked examples.

Standards of balance achieved by the arrangements shown here compare favourably with the results obtained from far more complicated and expensive balancing machines.

Definitions

Primary Balancing describes the process where primary forces caused by unbalanced mass components in a rotating object may be resolved into one plane and balanced by adding a mass in that plane only. As the object would now be completely balanced in the static condition (but not necessarily in dynamic) this is often known as **Static Balancing**.

Secondary Balancing describes the process where primary forces and secondary force couples caused by unbalanced mass components in a rotating object may be resolved into two or more planes and balanced by adding mass increments in those planes. This balancing process is often known as **Dynamic Balancing** because the imbalance only becomes apparent when the object is rotating. After dynamic balancing, the object would be completely balanced in both static and dynamic conditions.

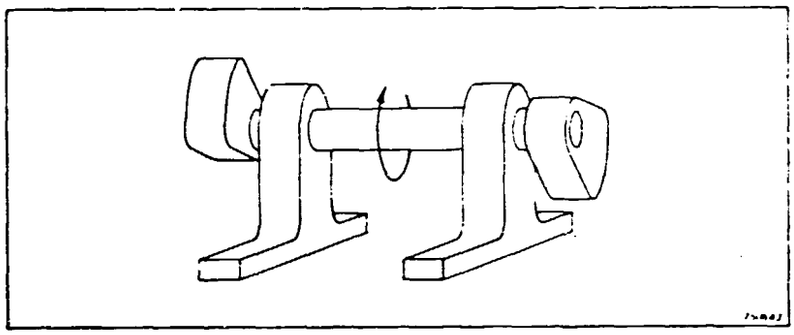

Fig.1. Static Balance, Dynamic Imbalance

The difference between static balance and dynamic balance is illustrated in Fig.1. It will be observed that when the rotor is stationary (static) the end masses may balance each other. However, when rotating (dynamic) a strong imbalance will be noted.

Background

When an unbalanced object rotates, it imparts a vibration to its bearings, usually at rotation frequency or one of the harmonics, due to the rotating force caused by the unbalanced masses. The vibration at a bearing will be made up from a component due to unbalanced (primary) forces in or very close to the plane of the bearing, and a couple component due to unbalanced (secondary) forces in the other planes. If an accelerometer is mounted on the bearing housing, the vibration can be detected and a signal fed to a vibration meter. The vibration level indicated on the meter is directly proportional to the resultant of the out of balance masses.

It is possible to find the line of action of the resultant unbalanced force by comparing the phase of the oscillating output from the vibration meter with a periodic signal obtained from some datum position on the rotor. Then the imbalance at the bearing can be defined as a vector whose angle gives the line of action, and length the magnitude of the unbalanced mass. Further, if the resultant unbalanced force at a bearing can be resolved into primary and secondary components, it will be possible to balance a rotor by removing mass increments along the radius of the imbalance, or by adding mass increments on the opposite side.

Many rotating parts which have most of their mass concentrated in or very near one plane, such as flywheels, grindstones, car wheels, etc., can be treated as static balancing problems. This greatly simplifies the calculations, as only primary forces need be considered, and all secondary couples are assumed to be zero.

Measurement

Practical considerations

The rotor to be balanced should be easily accessible, and should have provision for mounting trial masses at various angles around it. The mounting points should preferably be at the same radius from the axis of rotation to simplify calculation. The datum position must be marked on the rotor in such a way that it triggers a pick-up installed alongside it on the stationary part of machine. A non-contacting type of pick-up is recommended, because this will give the rotor the minimum of disturbance.

Vibration level measurements can be made in terms of acceleration, velocity, or displacement. Acceleration levels will tend to emphasize higher frequencies while displacement will emphasize low frequencies, so if neither of these condition is specifically required, velocity measurement is recommended as this gives equal emphasis to all frequencies.

Instrumentation

The basic measuring arrangement, shown in Fig 2, consists of an accelerometer, a vibration meter, and a means of determining the angle of the imbalance releative to the datum position. The most effective method of measuring this angle is to use a phase meter as shown, but a stroboscope can also be used (see Fig 3), or the angle can be deduced from the results of several measurements. The Magnetic Transducer MM 0002 emits a pulse each time the High-μ Disc passes, and thus establishes a datum position on the circumference of the rotor. The transducer output is fed to the reference channel (A) of the Phase Meter Type 2971. The output from the Accelerometer Type 4338 is fed to the Vibration Meter Type 2511, which displays the vibration level. A signal taken from the "Recorder Output" of the Vibration Meter is fed to channel B of the Phase Meter.

When the machine is run, a vibration level will be displayed on the Vibration Meter, and an angle on the Phase Meter, which together give a vector representing the unbalanced mass and its line of action.

Various modifications and additions can be made to the instrument arrangement shown in Fig 2 to improve selectivity, or to take advantage of instruments that are already at hand. Figures 3 to 8 illustrate some of the possibilities.

The Vibration Meter Type 2511 can be replaced by the Type 2510 which can measure vibration velocity in the frequency range between 10 Hz and 1000 Hz. When the Type 2510 is used without a filter, as in Fig.4, the signal for channel B of the Phase Meter can be taken from the Output to External Filter socket on the 2510. Note that in this arrangement, the External Filter switch should be in position "Off" so that there is still an indication of the level on the meter.

If it is impossible to fasten a High-μ Disc onto the rotor, the WQ 2091 Photodiode can be used. This can scan the rotor to pick up a triggering mark that can be a piece of adhesive tape, or a painted patch with a colour contrasting with the background. The Photodiode must be connected to a power supply unit

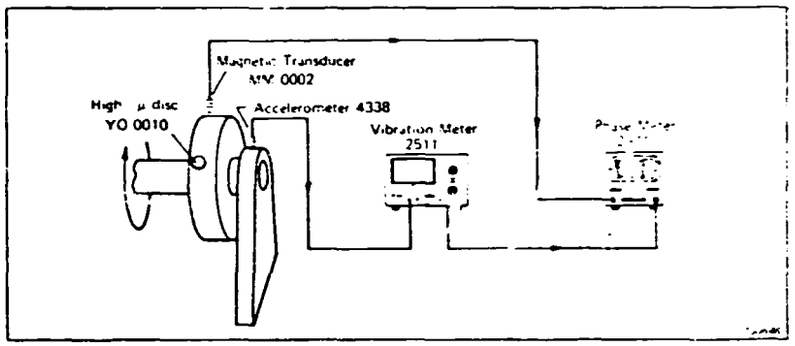

Fig.2. The basic measuring chain

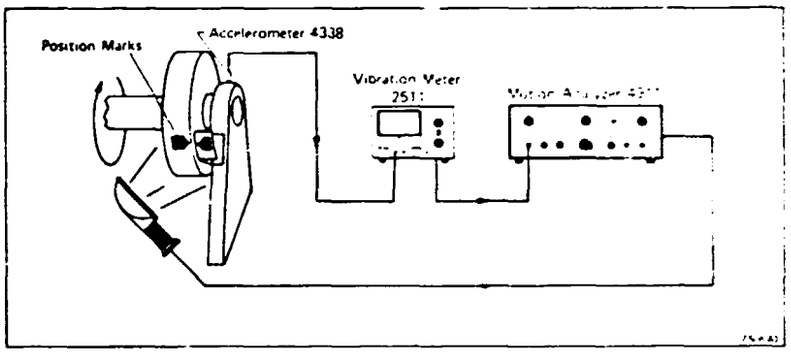

Fig.3. Arrangement using a stroboscope to measure angles

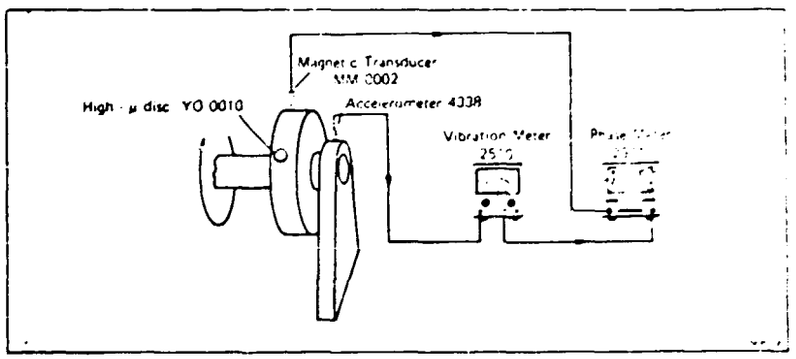

Fig.4. Arrangement using the Vibration Meter 2510

to energise the lamp. Suitable units are the Tacho Unit Type 5586, shown in Fig 5, which is also able to indicate the rotational speed (accuracy better than ± 2%), or the less sophisticated Control Unit Type 5533

Another very useful addition to the measuring arrangement is the Tunable Band Pass Filter Type 1621 which ensures that the Phase Meter (or Stroboscope) receives a clean input signal. It is recommended for installations where the required triggering signal would otherwise be buried in noise, or where high vibration levels occurring at several frequencies cause difficulties in signal tracking. The Filter is connected as external filter to either of the Vibration Meters (Fig 5, 6, and 7). Note that with the Type 2510 the signal for channel B of the Phase Meter is now taken from the "Input from External Filter" as shown in Fig 6, and that the External Filter switch should be in position "On". The Band Pass Filter has two bandwidths, 3% and 23%, that can be tuned continuously from 0,2 Hz to 20 kHz to match the rotational speed of the machine. It can also be used to find the relative levels of vibration at rotational speed and at the various harmonics, because with some procedures, the harmonic levels may have to be balanced too.

In use the Band Pass Filter must be very carefully tuned because when it is slightly off tune, so that the vibration signal falls on the shoulder of the filter curve, phase deviation can be introduced. One way to avoid this problem is to tune the desired frequency as accurately as possible using the 3% bandwidth, and then to switch over to the 23% bandwidth to take advantage of the wider peak in the filter characteristic while making the phase measurement

A more effective alternative method that allows the advantages of the 3% band to be kept while vibration levels and phase angles are being measured makes use of the Switch WB 0192 in an arrangement like that illustrated in Fig 7. The Switch is used as follows, to determine and eliminate the phase deviation produced by the narrow band Filter alone. The Slope switches on the Phase Meter are arranged with "+" on Channel A and "—" on Channel B, so that when the inputs are in phase, measurements in the 0 to 360° (0 to 6,28 rad) range will produce a stable reading of 180° (3,14 rad) on the digital display, while the pointer on the analog meter will be steady in the middle of the scale at π. "Reference" is selected on the WB 0192 so that the datum signal from the Photo Probe (or Magnetic Transducer) is divided, with one part passing directly to Input A, while the other part passes via the Filter to Input B. The Filter is swept slowly through the frequency range where the rotation frequency is expected to lie. When the pointer of the analog meter stops sweeping from one end of the scale to the other and stabilizes in the middle of the scale at π, the Filter can be finely tuned with the aid of the digital

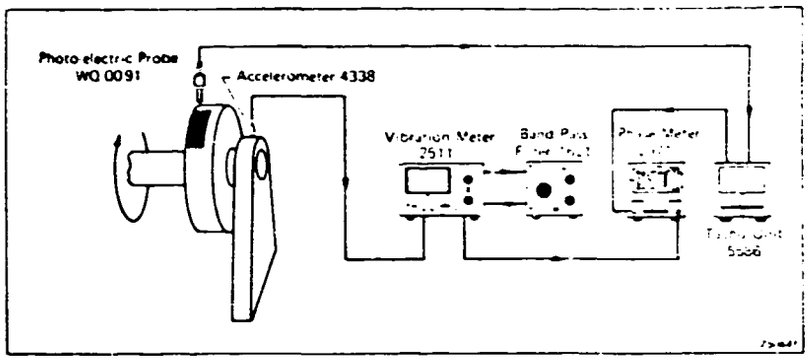

Fig.5. Arrangement using a Band Pass Filter and Photodiode triggering with Tachometer

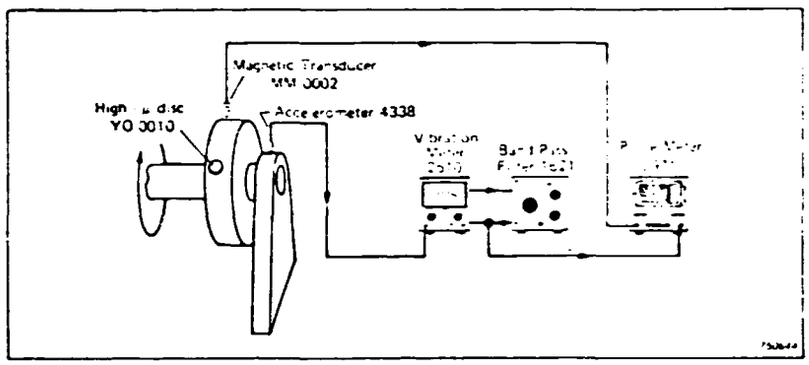

Fig.6. Vibration Meter 2510 used with Filter 1621

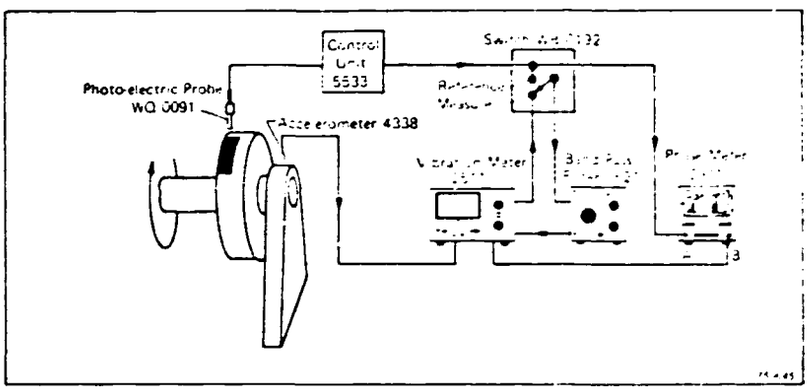

Fig.7. Recommended arrangement incorporating phase correction Switch WB 0192

display until a reading of 180° (3.14 rad) appears. Because the input and output of the Filter are now in phase, the centre frequency of the Filter is accurately tuned to the rotation frequency, thereby eliminating any phase errors introduced by the Filter. Without changing the Filter setting, both slope switches on the Phase Meter are set to "+" (or both to "—"). "Measure" is selected on the WB 0192 Switch, so that the Filter operates on the vibration signal derived from the Accelerometer. The vibration level is indicated by the Vibration Meter, while the angle measured by the Phase Meter is the actual phase angle of the unbalanced mass referred to a datum. It should be stressed that this datum is not the same as the plane from which the Phase Meter obtains the triggering signal, because the Phase Meter is triggered by a zero crossing, while the Vibration Meter measures RMS or peak-to-peak.

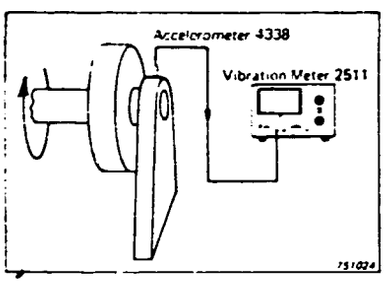

Fig 8. Simplified arrangement using only vibration meter and accelerometer

The greatly simplified measuring arrangement shown in Fig 8 can also yield results that can be used in balancing a rotor. The procedure is not quite the same as for the other measuring arrangements, it will be explained in Example 3. As the methods used with the other arrangements are all basically similar to each other, worked examples will not be presented for each arrangement.

All the measuring arrangements described and illustrated here are equally suitable for both static and dynamic balancing.

Static Balancing

Examples

Example 1. To statically balance a rotor using a Motion Analyzer Type 4911 to measure phase angles with the arrangement shown in Fig 3.

The Vibration Meter was switched to measure vibration "Velocity", to obtain equal emphasis of both low and high frequencies, the internal filters in the Vibration Meter were used to restrict the measuring range to frequencies between 10 Hz and 1000 Hz, to improve the signal to noise ratio. Peak-to-peak measurement with one second time constant was chosen so that a large and responsive needle deflection could be obtained. An AC signal from the "Recorder Output" of the Vibration Meter was fed to one of the "Input" terminals of the Motion Analyzer to be used as a triggering signal. The Analyzer was switched to "External Synchronised" mode so that the lamp would blink at rotation frequency. A position mark was made on the rotor, with another alongside it on the stationary part of the machine.

The machine was run up to its operating speed (2800 rpm), and a vibration velocity level of 15 mm/s indicated by the Meter. Because the flashing of the lamp was synchronised with the rotation, when the machine was observed by its light, the rotor appeared to be stationary. Turning the "Phase Deviation" knob allowed the position mark on the rotor to be lined up with the stationary mark on the machine. The "Phase Deviation" control is graduated in 10° steps so that it was possible to estimate a phase angle of 55°, after which the machine was stopped. Together, the velocity level and the phase angle give a vector representing the original imbalance of the rotor V_0 in Fig 9.

A trial weight of known mass was fixed at a known radius on the rotor at the same angular position as the reference mark. A mass with sufficient magnitude to have a pronounced effect on the rotor must be used for the first trial. In the example, a trial mass of 5 g was fixed to the rotor, and then the machine was run up to its operating speed again. The new vibration velocity level was 18 mm/s, and when the two marks had been lined up with each other again by the "Phase Deviation" control the new phase angle was found to be 170°. These values represent the resultant effect of the initial unbalance and the 5 g trial mass, which is shown as vector V_1 in Fig 9.

Now sufficient information was available for the vector diagram in Fig 9 to be constructed, with vector lengths proportional to the measured vibration velocity levels obtained from the Vibration Meter, and angles being those measured by the Motion Analyzer. As Vector V_1 is the resultant of the initial imbalance plus the 5 g mass, vector V_T can be found, which represents the trial mass alone. The length of V_T is proportional to the 5 g mass, so that the length of vector V_0, the initial imbalance can be determined in mass units. The angle of V_T gives the position at which the trial mass was fastened, so that it is a simple matter to deter-

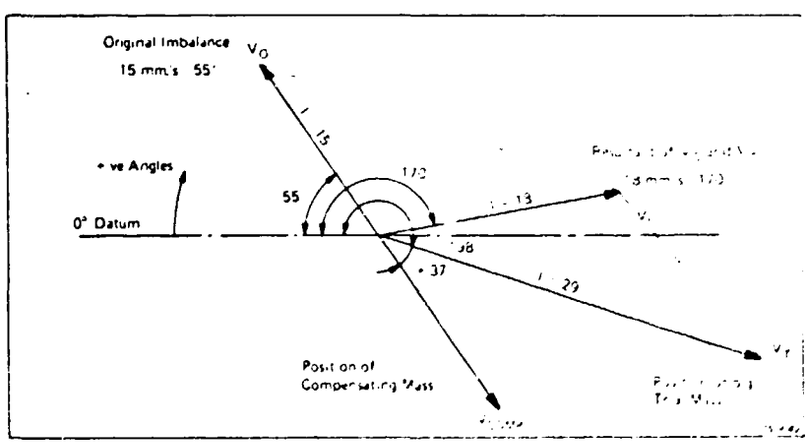

Fig 9. Vector diagram for Example 1

mine the angle the initial imbalance makes with the position of the trial mass so that the angular position for the compensating mass can also be found

The original imbalance is given by

$$M_o = \frac{V_o}{V_T} \times M_T$$

$$= \frac{15}{29} \times 5 = 2.6\,g$$

So the compensating mass
$M_{COMP} = 2.6\,g$

And its position is given by
$\angle_{COMP} = -\angle_T + \angle_o + 180°$
$= -198° + 55° + 180°$
$= +37°$ referred to the position of the Trial Mass

The positive angle means that the compensating mass is to be fastened at 37° from the trial mass position in a positive direction, that is, in the direction of rotation.

After the rotor has been balanced by this procedure, it is recommended that the vibration level be measured again to check the standard of balancing obtained. Often, due to non-linearities or inaccuracies in the practical measuring arrangement, the rotor will not have been sufficiently well balanced by one application of the balancing procedure. When the level of the residual imbalance is unacceptably high, the whole balancing procedure must be reiterated, until an acceptable level is achieved.

Example 2. To statically balance a rotating machine using the arrangement shown in Fig 5 to measure vibration levels and phase angles

Measurement of peak-to-peak vibration velocity level was selected on the Vibration Meter, and a bandwidth of 3% on the Band Pass Filter. The machine was run up to its normal operating speed (1490 rpm on the Tacho Unit), after which the band pass filter centre frequency was adjusted to give the highest indicated level of vibration velocity on the Vibration Meter. A vibration level of 3.4 mm/s was recorded, and when the bandwidth was broadened to 23%, the Phase Meter indicated + 116°.

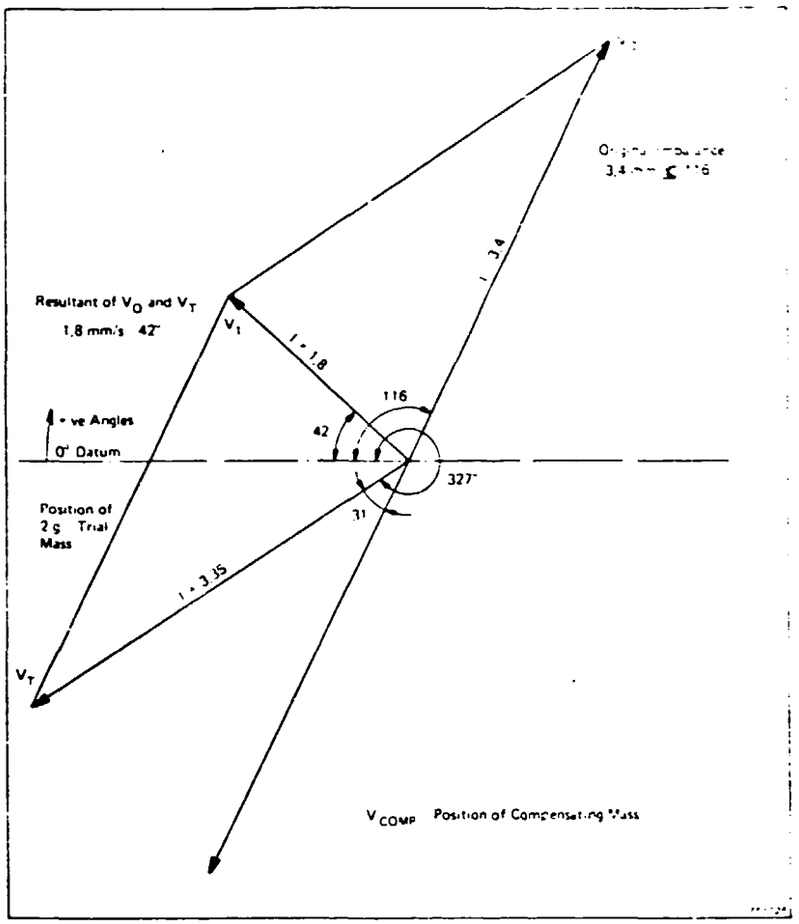

Fig.10. Vector diagram for Example 2

The machine was stopped, and a 2 g trial mass fixed to it. When the machine was running again, the vibration velocity level was found to have decreased to 1,8 mm/s, and the phase angle was found to have changed to + 42°.

The vector diagram in Fig 10 was drawn so that the position and magnitude of the compensating mass could be determined.

The original imbalance is given by

$$M_o = \frac{3.4}{3.35} \times 2 = 2.03\,g$$

So the compensating mass
$M_{COMP} = 2.03\,g$

And its position is given by
$\angle_{COMP} = -327° + 116° + 180°$
$= -31°$ referred to the trial mass position

As the angle indicated is negative, the compensating mass is to be fastened at 31° in the negative direction from the trial mass, which is the opposite direction from the rotation

Example 3. To statically balance a rotating machine, using only a Vibration Meter, and an Accelerome-

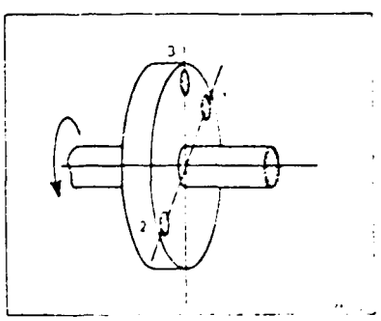

Fig 11. Positions of the trial mass used in Example 3

ter in the arrangement shown in Fig 8

This method requires four vibration measurements to be made at the bearing. A trial mass will be required which can be mounted at the same radius in three different positions at 90° from each other, as shown in Fig 11

The machine was run, to establish the vibration velocity level caused by the original imbalance, this was found to be V_o = 2.6 mm/s. A 10 g trial mass was fastened to the rotor in position 1, and the machine run again. This gave a vibration level of V_1 = 6.5 mm/s due to the combined effect of the trial mass and the initial unbalanced mass. Before the next run, the trial mass was moved 180° round the rotor and fastened at the same radius in position 2. The machine was run, and the vibration level was found to have decreased to V_2 = 1.9 mm/s

It was now possible to start to draw the vector diagram, however only the vecter lengths were known, but not the angles. Nevertheless, circles could be drawn about a common centre, each having a radius equivalent to a vector length, i e the measured vibration level. Referring to the Geometry diagram in Fig.12, two circles have been drawn with radii proportional to V_1 and V_2 the two resultants of the original imbalance and the trial mass fastened in two positions at 180° from each other. A radius has also been drawn at an arbitrary angle in each circle. Identical parallelograms have been constructed using each radius as a diagonal, and taking the line from the centre of the circles to the midpoint of the line joining the ends of V_1 and V_2 as a common side

It will now be seen that if the angles of V_1 and V_2 can be arranged to produce a common side with length equivalent to V_o, then the diagram will give a true representation of the vectors, so that the other side in each parallelogram must be equivalent to V_T, the vibration caused by the trial mass alone in positions 1 and 2. Furthermore, the following relationships exist.

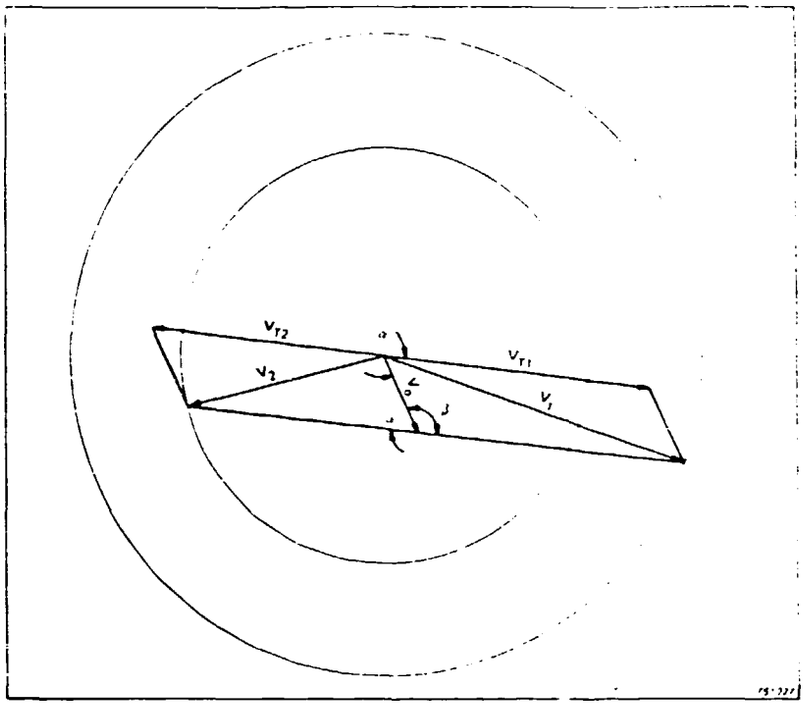

Fig.12. Geometry for Example 3

$$V_2^2 = V_{T2}^2 + V_0^2 - 2V_{T2}\,V_0 \cos\alpha$$

$$V_1^2 = V_{T1}^2 + V_0^2 - 2V_{T1}\,V_0 \cos\beta$$

and as $\cos\beta = \cos(180° - \alpha)$

$$= -\cos\alpha$$

Equation 2 simplifies to,

$$V_1^2 = V_{T1}^2 + V_0^2 + 2V_{T1}\,V_0 \cos\alpha$$

So that $V_{T1} = V_{T2}$

$$= \sqrt{\frac{V_1^2 + V_2^2 + 2V_0^2}{2}}$$

and $$\alpha = \cos^{-1}\frac{V_1^2 - V_2^2}{4V_T\,V_0}$$

However, as $\cos\alpha = \cos(-\alpha)$ it is not immediately obvious whether the vector for the original imbalance, V_o lies above or below the $V_{T2} - V_{T1}$ axis (i e the line joining trial mass position 1 with position 2). Therefore it was necessary to make another test run, with the trial mass fastened in position 3, to give Vector V_3. Strictly it was not necessary to draw this vector, as if the vibration level were greater than that from the trial mass alone V_T, then V_o would lie above the $V_{T2} - V_{T1}$ axis (shown as full line in Fig 13). If the vibration level were less than V_T, V_o would lie below the $V_{T2} - V_{T1}$ axis, shown with broken line in Fig 13

As a result of mounting the trial mass in position 3, when the machine was run, a vibration velocity level of V_3 = 5.5 mm/s was recorded, thereby indicating that the original imbalance vector should lie above the $V_{T2} - V_{T1}$ axis

Substituting the vibration values of V_o, V_1, and V_2 into equation 4.

$$V_T = \sqrt{\frac{6.5^2 + 1.9^2 - 2 \times 2.6^2}{2}}$$

$$= 4 \text{ mm/s}$$

And now using equation 5.

$$\alpha = \cos^{-1}\frac{6.5^2 - 1.9^2}{4 \times 4 \times 2.6}$$

$$= \cos^{-1} 0.9288$$

$$= \pm 21.74°$$

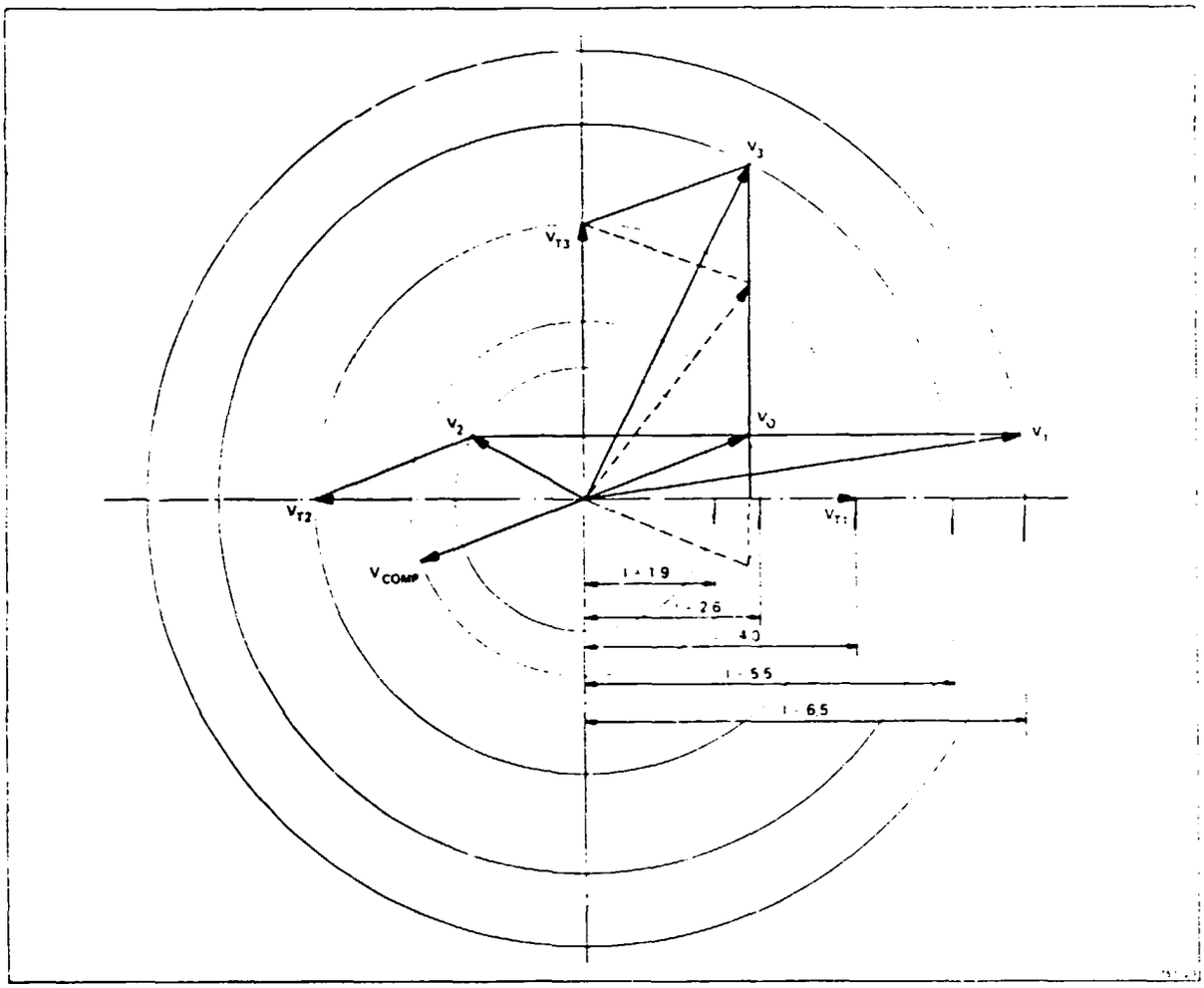

Fig.13. Vector diagram for Example 3

And because V_o has been found to lie above the $V_{T2} - V_{T1}$ axis, i e at 21.74° from position 1 towards position 3, the compensation mass must be fastened at 21.74° below position 2.

The magnitude of the balancing mass is found as before,

$$M_{Comp} = M_o = \frac{V_o}{V_T} \times M_T$$

$$= \frac{2.6 \times 10}{4}$$

$$= 6.5\,g$$

Dynamic Balancing Examples

Example 4. To balance a machine that has a rigid rotor supported in two bearings both statically and dynamically, i e a balancing problem in two planes. The measuring arrangement shown in Fig 7 was employed in this example, and the basic method used can be extended to solve balancing problems in more than two planes.

The procedure is the same as in the foregoing examples, finding the effect of a known trial mass attached to the rotor, except that now measurements have to be made in two planes (at the two bearings). Two sets of measuring instruments can be used, with a set at each bearing to determine the vibration levels and phase angles produced, so that all necessary data can be obtained from only three test runs. Alternatively, a single set of equipment can be used, with the accelerometer being moved from one bearing to the other, or the Vibration Meter can be switched between two accelerometers, one at each bearing.

To avoid special emphasis of high or low frequencies, vibration velocity was chosen as the measure of vibration level on the Vibration Meter, and the 3% bandwidth selected on the Tunable Band Pass Filter. The Phase Meter upper frequency limit was set at "2 kHz" to eliminate unwanted high frequency signals, while the lower limit was set at "2 Hz" to take advantage of the longer averaging time to obtain a steadier phase indication.

As a first step, the vibration velocity levels and phase angles had to be measured at each bearing to establish the magnitude of the original imbalance. The WB 0192 Switch was put on "Reference" setting, and the Phase Meter slope switches set to "+" on Channel A and "—" on Channel B. The machine was run, and the filter tuned slowly through the rotational frequency until a steady reading of 180° was displayed on the Phase Meter, indicating that the Filter was accurately tuned on the rotational frequency. The Phase Meter slope switches were both set on "+", (they could both have been set on "—"), and the WB 0192 switched to "Measure" so that the accelerometer signal was passed through the Filter. The Vibration level (V) and the phase angle (γ) were measured at both bearings. Then a known trial mass was mounted at a known radius on the rotor near one of the bearings, and a test run made to find the effect of the trial mass, both on the nearby bearing, and on the other bearing too. The machine was stopped, and the trial mass moved to the same radius and angle near the other bearing. Another test run was made to find the effect on the bearings of the trial mass in its new position.

The results have been arranged in Table I and a vector notation for each measurement has also been included. The notation represents the complete vector, both vibration level (length) and phase angle, in one convenient term. It also indicates the plane in which the measurements were made and the plane where the trial mass (if any) was fastened. So that $\bar{V}_{1.0}$ represents a vibration level V and a phase angle γ measured in Plane 1, and no trial mass on the rotor $\bar{V}_{1.2}$ represents a vibration level V and phase angle γ measured in Plane 1 when a trial mass is fastened to Plane 2, and so on.

The measured vibration levels and angles from the Table could be used to draw vector diagrams similar to those shown in Fig.15. Furthermore, it can be seen from the vector diagrams that in terms of vector notation

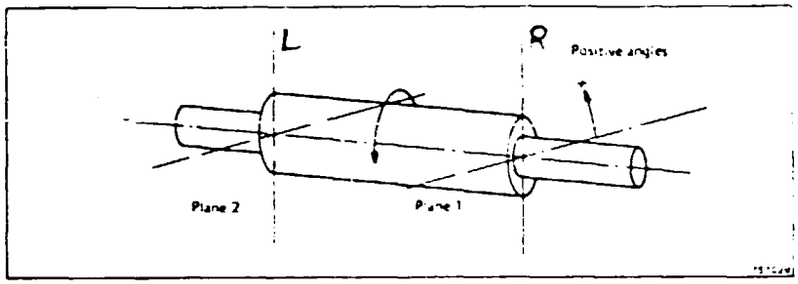

Fig.14. The rotor, showing the measuring planes

Trial Mass Size and Location	Measured Effect of Trial Mass					
	Plane 1			Plane 2		
None	7.2 mm/s	238°	$\bar{V}_{1.0}$	13.5 mm/s	296°	$\bar{V}_{2.0}$
2.5 g on Plane 1	4.9 mm/s	114°	$\bar{V}_{1.1}$	9.2 mm/s	347°	$\bar{V}_{2.1}$
2.5 g on Plane 2	4.0 mm/s	79°	$\bar{V}_{1.2}$	12.0 mm/s	292°	$\bar{V}_{2.2}$

Table 1. Measured vibration levels and phase angles

V	V	γ	a	jb
$\bar{V}_{1.0}$	7.2	238°	—3.82	—6.12j
$\bar{V}_{1.1}$	4.9	114°	—2.0	+ 4.48j
$\bar{V}_{1.2}$	4.0	79°	+ 0.76	+ 3.93j
$\bar{V}_{2.0}$	13.5	296°	+ 5.92	—12.13j
$\bar{V}_{2.1}$	9.2	347°	+ 8.96	—2.07j
$\bar{V}_{2.2}$	12.0	292°	+ 4.5	—11.13j
$(\bar{V}_{1.1} - \bar{V}_{1.0})$	[illegible]	[illegible]	+ 1.82	+ 1060j
$(\bar{V}_{2.1} - \bar{V}_{2.0})$	[illegible]	[illegible]	+ 3.04	+ 10.06j
$(\bar{V}_{1.2} - \bar{V}_{1.0})$	[illegible]	[illegible]	+ 4.58	+ 10.05j
$(\bar{V}_{2.2} - \bar{V}_{2.0})$	[illegible]	[illegible]	—1.42	+ 1.00j

Table 2. Conversion of coordinates

$\bar{V}_{1.1} - \bar{V}_{1.0}$ is the effect in Plane 1 of a trial mass in Plane 1.
$\bar{V}_{1.2} - \bar{V}_{1.0}$ is the effect in Plane 1 of a trial mass in Plane 2.
$\bar{V}_{2.1} - \bar{V}_{2.0}$ is the effect in Plane 2 of a trial mass in Plane 1.
$\bar{V}_{2.2} - \bar{V}_{2.0}$ is the effect in Plane 2 of a trial mass in Plane 2.

Each of the vector diagrams in Fig.15, is analogous to the vector diagrams in the earlier examples. However, when an unbalancer mass (trial mass) is applied at one measuring plane, it has an effect on both planes. Therefore for complete balance of the rotor, masses must be added in both end planes, in such a way that produces vibration vectors with equal magnitude (length) to

$V_{1,0}$ and $V_{2,0}$, but which have opposite phase angles. Mathematically, the problem is to find two vector operators $\vec{Q}_1$ (with vector length Q_1 and phase angle q_1) and $\vec{Q}_2$ (Q_2 and q_2) which satisfy the following equations:

$$(\vec{V}_{1,1} - \vec{V}_{1,0}) \times \vec{Q}_1 + (\vec{V}_{1,2} - \vec{V}_{1,0}) \times \vec{Q}_2 = -\vec{V}_{1,0} \quad \text{Eqn 6}$$

$$(\vec{V}_{2,1} - \vec{V}_{2,0}) \times \vec{Q}_1 + (\vec{V}_{2,2} - \vec{V}_{2,0}) \times \vec{Q}_2 = -\vec{V}_{2,0} \quad \text{Eqn 7}$$

These expressions can be solved as a pair of equations with 2 unknowns $\vec{Q}_1$ and $\vec{Q}_2$. First find $\vec{Q}_1$ in terms of $\vec{Q}_2$.

$$\vec{Q}_1 = \frac{-\vec{V}_{1,0} - (\vec{V}_{1,2} - \vec{V}_{1,0}) \times \vec{Q}_2}{(\vec{V}_{1,1} - \vec{V}_{1,0})} \quad \text{Eqn 8}$$

and then solving for $\vec{Q}_2$.

$$\vec{Q}_2 = \frac{\vec{V}_{2,0}(\vec{V}_{1,1} - \vec{V}_{1,0}) - \vec{V}_{1,0}(\vec{V}_{2,1} - \vec{V}_{2,0})}{(\vec{V}_{2,1} - \vec{V}_{2,0})(\vec{V}_{1,2} - \vec{V}_{1,0}) - (\vec{V}_{2,2} - \vec{V}_{2,0})(\vec{V}_{1,1} - \vec{V}_{1,0})} \quad \text{Eqn 9}$$

The measured values of vibration level and phase angle in Table 1 are the polar coordinates for the vector quantity $\vec{V}$. When a Cartesian system of coordinates is used, with real and imaginary components where.

$$\vec{V} = a + jb \quad \text{Eqn.10}$$

a mathematical solution for Equations 8 and 9 can be calculated.

Polar coordinates can be converted to Cartesian by use of the two equations.

$$a = V \cos \gamma \quad \text{Eqn.11}$$

$$b = V \sin \gamma \quad \text{Eqn.12}$$

so that the values in Table 2 can be calculated.

Substituting real and imaginary values into Equation 9:

$$\vec{Q}_2 = \frac{(+5,92 - 12,13j)(+1,82 + 10,60j) - (-3,82 - 6,12j)(+3,04 + 10,06j)}{(+3,04 + 10,06j)(+4,58 + 10,05j) - (-1,42 + 1,00j)(+1,82 + 10,60j)}$$

Which simplifies to:

$$\vec{Q}_2 = +0,1598 - 1,1264j$$

Which can be reconverted to polar coordinates by means of the following equations:

$$V = +\sqrt{a^2 + b^2} \quad \text{Eqn 13}$$

$$\text{for } a > 0 \qquad \gamma = \tan^{-1}\frac{b}{a} \qquad -90° < \gamma < +90° \quad \text{Eqn 14}$$

$$\text{for } a < 0 \qquad \gamma = 180° + \tan^{-1}\frac{b}{a} \qquad +90° < \gamma < +270° \quad \text{Eqn 15}$$

So that vector length, $V_2 = 1,1376$ (mm/s)

and phase angle, $\gamma_2 = -81,9°$

Now these values can be substituted into Equation 8 so that $\vec{Q}_1$ can be found

$$\vec{Q}_1 = \frac{-(-3,82 - 6,12j) - (+4,48 + 10,05j)(+0,1598 - 1,1264j)}{(+1,82 + 10,6j)}$$

Which simplifies to

$$\vec{Q}_1 = +0,7468 + 0,9033j$$

And using Equations 13 and 14, the vector length and phase angle are found

$$V_1 = 1,1720 \quad (mm/s)$$

and $\gamma_1 = +50,4°$

Therefore the balancing masses to counteract the original imbalance of the rotor are as follows

Plane 1 M_{COMP}

$= 1,172 \times 2,5\,g$

$= 2,93\,g$ at $-50,4°$

(50,4° from the trial mass position in the direction of rotation)

Plane 2 M_{COMP}

$= 1,1376 \times 2,5\,g$

$= 2,84\,g$ at $-81,9°$

(81,9° from the trial mass position in the opposite direction from the rotation)

Masses with these values were fastened in the respective planes on the rotor at the calculated angles, and at the radius used previously for the trial masses. A test run was made to assess the quality of the balance. Its results were as follows

Plane 1 vibration level = 0,5 mm/s, which represents a reduction in vibration velocity level of 93% from the original 7,2 mm/s

Plane 2 vibration level = 0,4 mm/s, which represents a reduction in vibration velocity level of 97% from the original 13,5 mm/s

As an added test, the two balance masses were moved through an angle of 10° to find the importance of the phase angle determination. When the machine was run again the vibration velocity level at Plane 1 was found to be 1,8 mm/s, with 2,2 mm/s at Plane 2. These results illustrate the value of the really accurate phase angle determination possible with the Type 2971 Phase Meter.

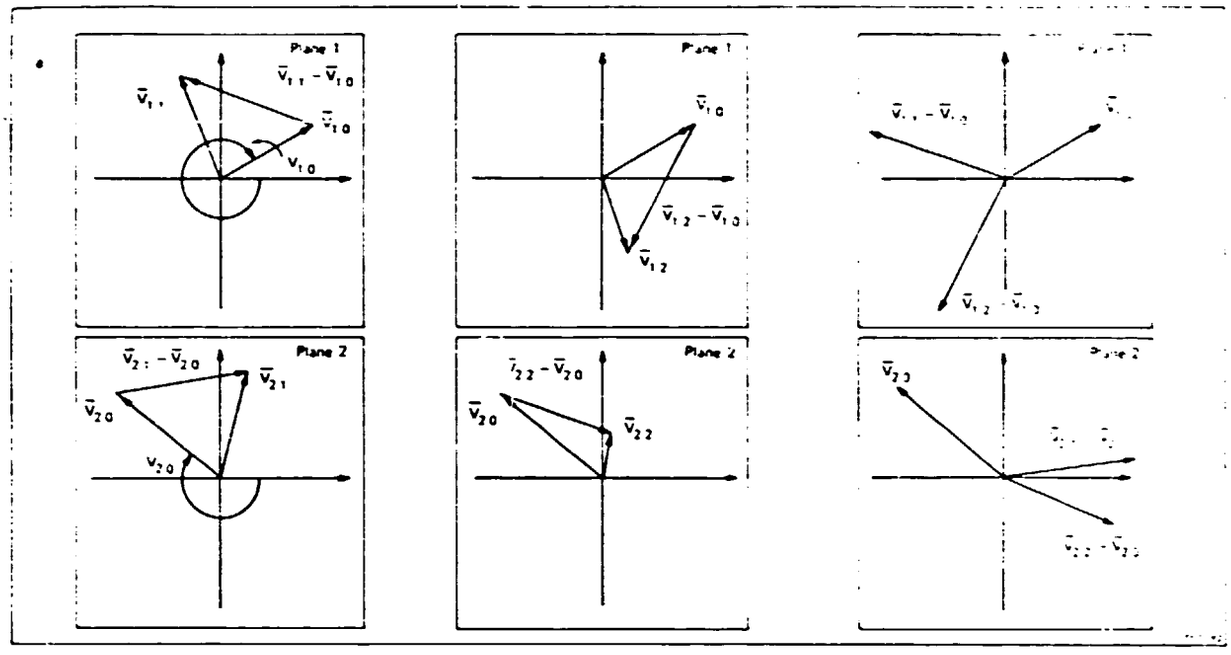

Fig.16. Vectorial representation of the vibration levels

Example 5. Dynamic balancing using a computer to make the calculations. In Example 4, calculations were made with the aid of a pocket electronic calculator, and the calculation process took about an hour to complete. A computer program in BASIC is available to speed up the calculation procedure. Fig.16 shows the program, the entry of data for a particular balancing problem, plus the calculated vector lengths, and phase angles of the result.

Table 3 contains the vibration levels and phase angles recorded for a machine being balanced using a measuring arrangement similar to that shown in Fig.3.

The data for calculation must be entered into the computer in the following order: $V_{1\,0}$, $\gamma_{1\,0}$, $V_{2\,0}$, $\gamma_{2\,0}$, $V_{1\,1}$, $\gamma_{1\,1}$, $V_{2\,1}$, $\gamma_{2\,1}$, $V_{1\,2}$, $\gamma_{1\,2}$, $V_{2\,2}$ and $\gamma_{2\,2}$. The vector lengths and phase angles for each plane are shown entered at statement 499 in the program. Total elapsed time to enter the data and make the calculation was of the order of two minutes.

The compensation masses to balance the rotor were calculated as in the previous example:

Trial Mass Size and Location	Measured Effect of Trial Mass					
	Plane 1			Plane 2		
None	170 mm/s	112°	$\bar{V}_{1\,0}$	53 mm/s	78°	$\bar{V}_{2\,0}$
1,15 g on Plane 1	235 mm/s	94°	$\bar{V}_{1\,1}$	58 mm/s	68°	$\bar{V}_{2\,1}$
1,15 g on Plane 2	185 mm/s	115°	$\bar{V}_{1\,2}$	77 mm/s	104°	$\bar{V}_{2\,2}$

Table 3. Measured vibration levels and phase angles

Plane 1 M_{COMP}

$$= 1{,}721 \times 1{,}15\,g$$

$$= \underline{1{,}98\,g \text{ at } 236{,}2°}$$

Plane 2 M_{COMP}

$$= 0{,}931 \times 1{,}15\,g$$

$$= \underline{1{,}07\,g \text{ at } 121{,}8°}$$

When masses with these values had been fastened at the correct angles and radius on the test rotor, new vibration levels were measured:

Plane 1 vibration level = 22 mm/s, an improvement of 87%.

Plane 2 vibration level = 8,5 mm/s, an improvement of 84%.

In this example, the slightly worse balance quality can be attributed to the use of a Motion Analyzer Type 4911 to determine the phase angles. As mentioned earlier, if the standard of balance achieved by adding the balance masses according to the results of the first series of measurements is not sufficient, the measurement and balancing sequence can be repeated for the new unbalanced condition.

```
SYMBAL VW 1326
LIST
 10  DIM C(2,2),D(2,2),E(2,2),F(2,2),G(2,2),H(2,2),I(2,2),J(2,2)
 12  DIM K(2,2),L(2,2),M(2,2),N(2,2),Ø(2,2),P(2,2),Q(2,2),R(2,2)
 14  DIM S(2,2),T(2,2),U(2,2),V(2,2),X(2,2)
 20  FØR Y= 1 TØ  6
 30  READ A(Y),B(Y)
 35  LET B(Y)=B(Y)*ATN( 1)/ 45
 40  NEXT Y
 50  LET C( 1, 1)=A( 1)*CØS(B( 1))
 60  LET C( 1, 2)=A( 1)*SIN(B( 1))
 62  LET C( 2, 1)=-C( 1, 2)
 65  LET C( 2, 2)=C( 1, 1)
 70  LET D( 1, 1)=A( 2)*CØS(B( 2))
 75  LET D( 1, 2)=A( 2)*SIN(B( 2))
 80  LET D( 2, 1)=-D( 1, 2)
 85  LET D( 2, 2)=D( 1, 1)
 90  LET E( 1, 1)=A( 3)*CØS(B( 3))
 95  LET E( 1, 2)=A( 3)*SIN(B( 3))
100  LET E( 2, 1)=-E( 1, 2)
105  LET E( 2, 2)=E( 1, 1)
110  LET F( 1, 1)=A( 4)*CØS(B( 4))
115  LET F( 1, 2)=A( 4)*SIN(B( 4))
120  LET F( 2, 1)=-F( 1, 2)
125  LET F( 2, 2)=F( 1, 1)
130  LET G( 1, 1)=A( 5)*CØS(B( 5))
135  LET G( 1, 2)=A( 5)*SIN(B( 5))
140  LET G( 2, 1)=-G( 1, 2)
145  LET G( 2, 2)=G( 1, 1)
150  LET H( 1, 1)=A( 6)*CØS(B( 6))
155  LET H( 1, 2)=A( 6)*SIN(B( 6))
160  LET H( 2, 1)=-H( 1, 2)
165  LET H( 2, 2)=H( 1, 1)
200  MAT I=E-C
205  MAT J=F-D
210  MAT K=G-C
215  MAT L=F-D
220  MAT M=H-D
225  MAT N=E-C
230  MAT Ø=D*I
235  MAT P=C*J
240  MAT Q=K*L
245  MAT R=M*N
250  MAT S=Ø-P
255  MAT T=Q-R
260  MAT U=INV(T)
265  MAT V=S*U
270  MAT I=C*M
275  MAT J=D*K
280  MAT K=I-J
285  MAT X=K*U
290  LET Y1=SQR(V( 1, 1)↑ 2+V( 1, 2)↑ 2)
300  LET Y2=SQR(X( 1, 1)↑ 2+X( 1, 2)↑ 2)
310  IF V( 1, 1)< 0 THEN 340
320  LET Y3= 0
330  GØTØ 350
340  LET Y3= 180
350  IF X( 2, 2)< 0 THEN 380
360  LET Y4= 0
370  GØTØ 390
380  LET Y4= 180
390  LET Y5=Y3+(ATN(V( 1, 2)/V( 1, 1)))/ATN( 1)* 45
400  LET Y6=Y4+(ATN(X( 1, 2)/X( 1, 1)))/ATN( 1)* 45
410  PRINT "MØDULUS AND ARGUMENT ØF C1:",Y2,Y6
420  PRINT "MØDULUS AND ARGUMENT ØF C2:",Y1,Y5
499  DATA  170, 112, 53, 78, 235, 94, 58, 68, 185, 115, 77, 104
510  END
RUN
MØDULUS AND ARGUMENT ØF C1:     1.78127          236.17
MØDULUS AND ARGUMENT ØF C2:     .930879          121.944
READY
```

Noise, Shock & Vibration Conference, 1974 Monash University, Melbourne.

VIBRATION SIGNATURE ANALYSIS – TECHNIQUES AND INSTRUMENT SYSTEMS

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Vibration signals measured at the external surfaces of a machine contain a great deal of information as to the internal processes and a number of monitoring and analysis techniques can be applied to extract information from these signals.

This paper discusses the area of applicability of the various techniques, which fall into three main categories:

(i) Field measurement with portable instruments.
(ii) Field recording followed by detailed analysis.
(iii) Permanent on-line monitoring.

Principles for the selection of suitable instrumentation and data processing systems are discussed, with respect to the types of information which can be extracted, the degree of complexity of the machine, and the amount of data to be handled.

The most important analysis technique is narrow band spectral analysis, and this can be carried out by normal swept-frequency techniques, high-speed swept frequency techniques or real-time analysis techniques. Where required, the spectrum can be obtained in digital form from analogue analyzers or by direct digital analysis. Other useful techniques include time domain averaging and cepstrum analysis.

Practical cases associated with machine health monitoring in a number of chemical plants are included as illustrations and a comprehensive bibliography is given in the paper.

It is a well-known fact that an experienced mechanic can detect by ear the development of many faults in for example an automobile engine, to the extent that the sound "signatures" of many such faults have acquired standard names: "piston slap", "bearing knock", "pinging" etc.

The concept of "vibration signature analysis" is in principle very similar: machines in good condition generally tend to have a fairly stable vibration pattern, which can be considered as a "signature". Changes in the internal conditions are often reflected by changes in the vibration pattern which can then be detected by externally mounted pick-ups while the machine is in operation.

The ability to monitor the condition of machines while in operation is very useful in preventive or "predictive" maintenance of continuously operating plant such as in the power generating and chemical industries, but the technique could also be of considerable use in machine development. The present paper is a general discussion of the many measurement and analysis techniques which have been and can be applied in "vibration signature analysis". The emphasis is laid on vibration rather than sound measurement because in the majority of cases this can be used to eliminate the further transmission process from the machine surface to the microphone. Furthermore, most of the information will be present in the vibration signals measured at the bearings, since it is here that most of the dynamic forces are transmitted from the moving parts to the housing. ("Bearings" are taken to include sliding bearings such as cylinder walls in reciprocating machines).

The three main ways in which vibration measurement and analysis can be used for machine monitoring are:

(i) Field Measurement with portable equipment.
(ii) Detailed laboratory analysis usually involving tape recording in the field.
(iii) Continuous monitoring with permanently installed pick-ups.

Before going into each of them in detail, it is as well to give a general indication of their areas of applicability and thus to put them in perspective.

Portable measuring instruments have the advantages of being relatively inexpensive and simple to operate and although they are limited to the measurement of overall vibration level or perhaps selective measurements at a few individual frequencies, this is adequate for the vast number of simple machines on most plants, eg. motors, pumps, fans etc.

The signals from more complex machines such as gearboxes, turbines, compressors and reciprocating machines will generally require more sophisticated analysis, at least to realise the full detective and diagnostic power which vibration monitoring can offer. This will mostly be justified with the more valuable and critical machines in the continuous process industries, where there are considerable benefits to be gained from more advance knowledge of impending failure and a better indication of its nature so that shutdown time can be minimized.

Finally, continuous monitoring will find application with the most critical machines, to guard against rapidly deteriorating situations and allow shutdown before catastrophic failure occurs. It is also useful for guarding against unstable areas of operation such as critical shaft speeds and oil whip in journal bearings.

Intermittent detailed analysis can often be used to advantage to supplement continuous monitoring on the same machine, the former giving more information about normal wear processes and the latter giving protection against sudden failure. In fact, in some industries it will be beneficial to employ all three types of vibration monitoring in parallel in the same plant.

TRANSDUCERS AND PREAMPLIFIERS.

Regardless of the further processing of the vibration signal, it has first to be converted to an electrical signal by a suitable transducer. Three types of transducers are currently in common use, which measure acceleration, velocity and relative displacement respectively.

For measurement of absolute motion, acceleration transducers, known as "accelerometers", are to be preferred for the following reasons.

(i) They have a very wide frequency range and dynamic range.
(ii) They have small mass and physical dimensions.
(iii) They are very rugged, and have no moving parts.
(iv) The acceleration signal can easily be integrated electronically to obtain a signal proportional to velocity or displacement, whereas the inverse process of differentiation is of dubious validity.

Velocity transducers were the first to be developed but have now been superseded by accelerometers in virtually all respects.

Relative displacement transducers are quite commonly built into large machines, but are primarily useful in cases where for example maintenance of working clearances is of greatest importance (1) and their use for signature analysis is limited by the frequency restriction inherent in displacement measurement.

Accelerometers have a high internal impedance, but this problem is now easily solved by using transistorized preamplifiers which convert from a high to a low impedance and which at the same time can be used for signal conditioning such as amplification and integration. Two types of preamplifiers are in use, "voltage preamplifiers" and "charge preamplifiers". The latter, though more expensive, are normally to be preferred as they give an output voltage which is independent of the cable length from the accelerometer. For further information see Ref. (2).

PORTABLE INSTRUMENTS.

When monitoring with portable instruments, it is desirable to simplify the operation as much as possible so that it can be carried out by people with a minimum of training.

It has been found from experience covering many types of rotating machinery that velocity is the best indicator of vibration severity over a wide frequency range. One explanation of this is that constant RMS velocity represents constant vibrational energy ie. components at different frequencies are weighted according to their energy levels. A common method of determining the vibration severity of a machine therefore, and one embodied in several standards([3), (4), (5]), is to measure the RMS value of the velocity over a wide frequency band (e.g. 10 - 1000 Hz) in order to include the effects of a large number of possible sources, and cater for a wide range of machines operating at different speeds.

These standards, in addition to specifying the method of measurement, also give recommended criterion levels, as illustrated in Fig.1. One must be careful not to give these absolute levels too much weight, however, since they are derived as averages over large numbers of machines and do not necessarily apply to any particular one. Reference (1), for example, describes how measurements of mechanical impedance at the bearing housings of a number of machines in the same class revealed a very wide range (>10:1) indicating that the forces resulting in a given velocity level would also vary over this range.

Another approach is to use the vibration level when the machine is known to be in good condition as a standard and take departures from this as the criterion of deterioration. The standard criteria (eg. Fig. 1) are still useful as a guide here, since the separation between the different grades there is 8 dB, and an increase of 20 dB is sufficient to change the classification from "Good" to "Inadmissible".

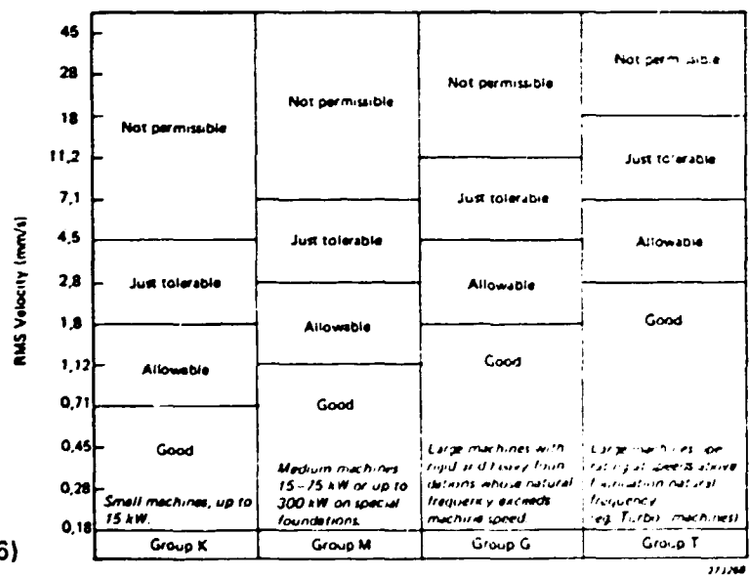

Fig. 1 Vibration Criterion Chart (VDI 2056)

Frequency Analysis

It is also possible to do some frequency analysis using portable equipment, and this is useful for two reasons:

(i) A rise in overall RMS level will indicate that something has changed internally but not give any information as to the cause. Frequency information can often indicate the source of a change as discussed under "Detailed Analysis".

(ii) Changes in minor spectral components, which may be the first indication of incipient failure, will not always affect the overall RMS level, but can be picked up by spectrum monitoring.

The two requirements are to some extent in conflict, since the first requires a narrow band resolution which would result in too many readings if it were desired to cover the complete spectrum for the second purpose. In practice therefore, some compromise must be made, with emphasis on one or the other factor.

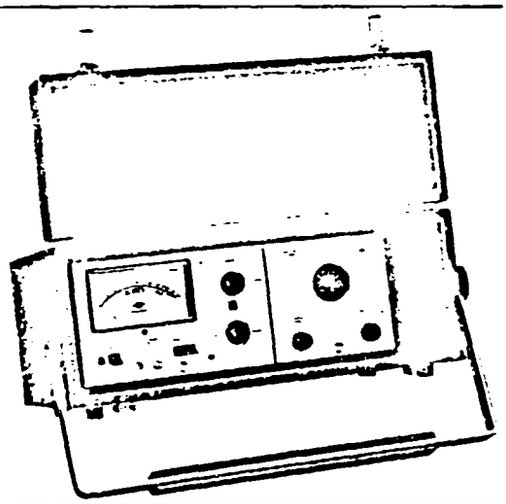

Fig. 2 Portable Vibration Set

A suitable portable battery-operated vibration monitoring set is illustrated in Fig. 2, housed in a rugged carrying case. It consists of a vibration meter with inbuilt charge preamplifier, capable of measuring RMS velocity according to the above-mentioned standards, but also acceleration and displacement. In addition there is a tunable narrow-band filter with bandwidths of 7% and 15%. With respect to the filter, it should be mentioned that bandwidth is not the only factor determining the resolution capability. The steepness of the filter characteristic outside the passband, as indicated by the "shape factor" or "Octave selectivity", is also very important.

Alternatively, some people prefer to monitor over a frequency range of 3 decades or so (6), so as not to miss changes which could occur at any frequency. Where the results from a large number of machines have to be noted down manually, it is not practicable to do this in bandwidths less than one octave. For this case a standard sound level meter with octave band filter set can be used, particularly if it has an integrator allowing measurement of velocity and displacement. The fact that the sound level meter is very useful in its own right will often influence this choice. Use of a 1/3-octave filter set represents a mid-way compromise.

DETAILED ANALYSIS

Using a portable tape recorder it is possible to bring the vibration signals into the laboratory where more detailed analysis can be carried out on them. The laboratory instruments are sometimes taken on-plant or to a control room to which the signals are led by long cables, and this may be suitable for individual measurements but it is not practicable for a regular monitoring scheme.

Tape Recording and Playback

The tape recording is an important part of the procedure, so it is worth discussing it in some detail. Firstly, the tape recorder itself should be chosen with care. Two recording principles are in common use viz. Direct Recording (DR) and Frequency Modulation (FM). Their relative merits are listed in Table 1.

	DR	FM
Dynamic Range (narrow band - typical)	70 dB	60 dB
Lower Frequency Limit	2.5 Hz*	DC
Upper Frequency Limit (typical)	50 kHz	10 kHz
Amplitude Stability	acceptable	excellent
Phase Linearity	poor	good
Preservation of Recorded Information	acceptable	good

*Playback speed 10x recording speed.

Table 1. Comparison of DR and FM recording techniques.

Perhaps the best compromise is a recorder with two channels FM (for most measurements) and two channels DR (for frequencies >10 kHz). It should of course be portable and battery-operated.

Since the tape recorder is likely to be the most limiting factor in determining the dynamic range of the system, it is wise to choose that parameter for recording (acceleration or velocity) which has the flattest spectrum, regardless of which is to be used for final evaluation. Conversion between the parameters is of course straight forward once a narrow band spectral analysis has been carried out.

There are several possibilities for playback of the signals for analysis:

(i) Continuous playback from the original tape reel. This will require unreasonably long recording times where analysis time is long.

(ii) Make up loops by cutting up the original tape reel. This is impractical for large numbers of signals.

(iii) Record directly on loop cassettes in the field. Also impractical for large numbers of signals.

(iv) Record over from the original tape reel to another recorder with permanently mounted tape loop for analysis. Requires two recorders.

In all cases where analysis is made from a tape loop, it may be found desirable to use a special weighting function to eliminate the effects of the tape splice (8, 9).

A better solution than (iv) would generally be to use a Digital Event Recorder in place of the second tape recorder since this eliminates the noise of the splice as such and allows a considerable reduction of analysis time by frequency transformation (9), as discussed later.

Spectral Analysis

The most usual analysis performed on the signals will be spectral analysis for the reasons already given, and in the laboratory it is possible to perform relatively narrow band analysis over the whole frequency range. It has been found that for many machines, the vibration power spectrum is very stable from time to time and even between different machines of the same type. This is the basis of a scheme developed by the U.S. Navy for onboard maintenance, and reported in Ref. (7). Shutdowns were based on departures from the envelope of standard signatures (Fig. 3) and the method was found to be justified by a statistical study of a large number of cases.

The question arises, however, as to the best way of presenting the results of such an analysis, and once again there is a conflict between covering a wide frequency range and requiring a fine resolution for diagnostic purposes.

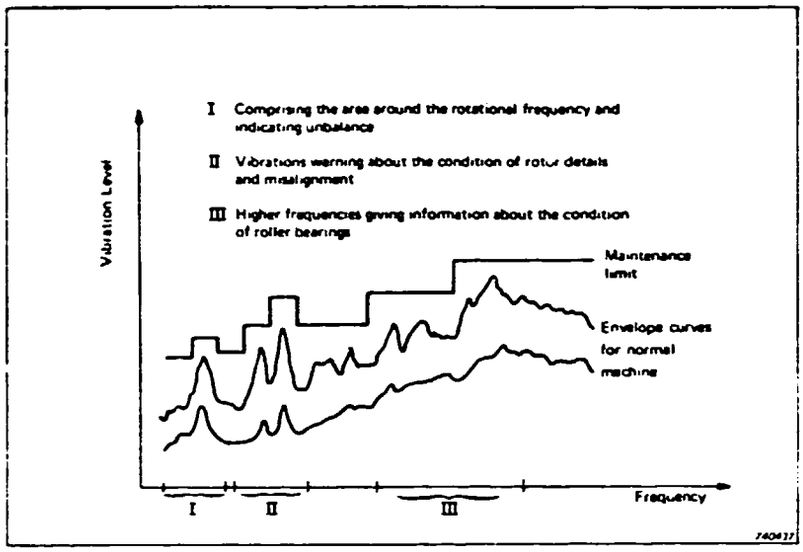

Fig. 3 Vibration Spectrum Envelopes

To cover a wide frequency range it is natural to use a logarithmic frequency scale, and then use of a constant percentage bandwidth (which gives uniform resolution) is almost unavoidable. Other reasons for using a logarithmic frequency scale (though not necessarily constant percentage bandwidth) are:

(i) Small changes in machine speed from time to time will only cause a lateral shift in the spectrum thus simplifying comparison.
(ii) Some relationships can most easily be seen in a log-log representation.

On the other hand if the signal being analyzed has a high harmonic content (e.g. gearbox vibrations) then it can be an advantage to obtain the analysis on a linear frequency scale with constant bandwidth which gives uniform resolution and equal separation of the harmonics. This point is discussed further under "Cepstrum Analysis".

The answer perhaps lies in using (approximately) constant percentage bandwidth analysis on a logarithmic frequency scale for detection of change, and constant bandwidth on a linear frequency scale for detailed diagnosis of changes. The same analyzer can perform both functions if its "constant" bandwidth can be made to step up automatically with increasing frequency, and if it has both linear and logarithmic frequency sweeps.

Analysis Methods

There are three main ways in which the power spectrum can be obtained:

(i) Using a narrow band sweep frequency analyzer (constant or constant percentage bandwidth). Analysis time typically 10 to 60 min. (See Ref. (10) for details).

(ii) High speed analysis using the same equipment as in (i) but with the addition of a Digital Event Recorder with which large speed transformations can be made on playback, thus increasing analysis speed considerably (9). Fig. 4 shows a typical instrument setup. Analysis time typically ½ to 3 min.

(iii) Real-time analysis using either the time compression principle (similar to (ii) or Fast Fourier Transform (FFT) techniques, and where the spectrum is continuously displayed on a screen. Fig. 5 shows a 400 line time compression analyzer.

Method (i) is only practicable where not many analyses have to be made, but it is worth examining the relative merits of (ii) and (iii), which are discussed in some depth below:

High Speed Analysis (ii) is somewhat cheaper in instrument cost than real time analyzers, typically ½ the cost of a Time Compression Analyzer and 1/4 the cost of an FFT analyzer. The saving is considerably more for people who already have the basic analysis system (i). It is also somewhat more flexible, the same setup offering both constant and approx. constant percentage bandwidth, log and linear frequency scales, and variable resolution up to the equivalent of 2500 lines. It can also be an advantage to be able to use the individual instruments separately; eg. the Digital Event Recorder has a multitude of other uses, and on the few occasions where 2500 line resolution is not adequate it is still possible to revert to a normal analysis setup to obtain any desired degree of resolution.

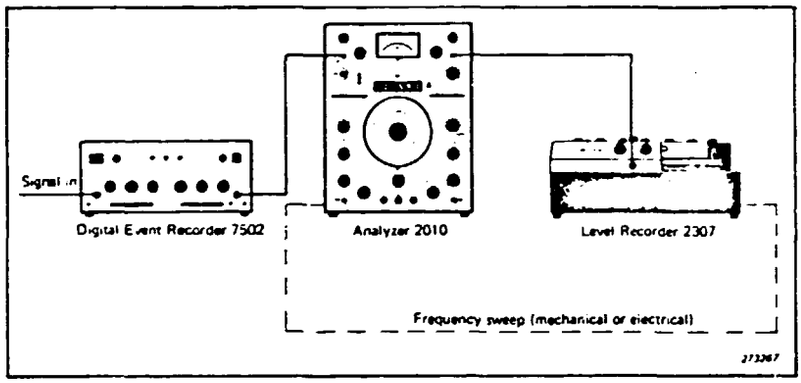

Fig. 4 Instrument Set-up for High Speed Analysis

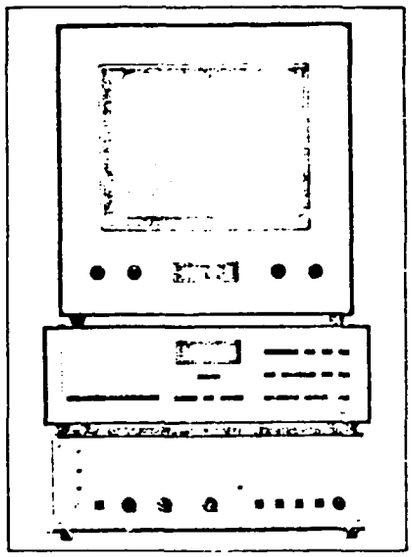

Fig. 5 Time Compression Analyzer

The same flexibility can be obtained with a real-time analyzer in combination with a general purpose computer, but this is of course even more expensive.

Real-Time Analysis (iii) has the principal advantage of being real-time, thus allowing the effects of changing conditions to be observed as they occur. In some cases, a transient phenomenon contains most information about the occurrence of damage, eg. turbine blade failure (11).

The use of digital averaging of a number of successive spectra to give adequate statistical reliability in the case of random signals can also be a considerable advantage in some cases. With the method (ii) the statistical reliability can only be improved by increasing bandwidth, but even so a 250 line (bandwidth) spectrum can be achieved with an RMS deviation $<1\frac{1}{2}$ dB. (BT product 10).

FFT analyzers have the additional advantage of being able to calculate cross correlations, cross spectra, transfer functions etc. thus providing considerable additional diagnostic power. (12).

Spectrum Diagnosis

The frequency at which a change in the spectrum occurs gives very important information as to the likely source, which is often related for example to the running speed.

The types of faults which can be detected and perhaps diagnosed from a frequency analysis (see also (1), (6), (7), (11), (13), (14), (15)) include unbalance (at shaft speed, primarily radial), misalignment and bent shafts (shaft speed and low harmonics, radial and axial), oil whip (just less than half shaft speed) and developing turbulence (blade and vane passing frequencies). Changes in natural frequencies can indicate crack growth or build-up of fouling. Local faults in rolling element bearings manifest themselves at frequencies corresponding to the rates of impact of the fault but also at higher frequencies (typically 20 - 60 kHz) corresponding to component natural frequencies (16, 13). Fig. 6 (from Ref. (16))shows the effect of induced pitting in an inner race.

Growth of sidebands indicates modulation at frequencies corresponding to the sideband spacings. This can for example indicate faults which cause modulation of the tooth meshing pattern in a gearbox (see later example). As another example, blade natural frequencies tend to frequency modulate the corresponding blade passing frequencies, providing another means of detecting these natural frequencies.

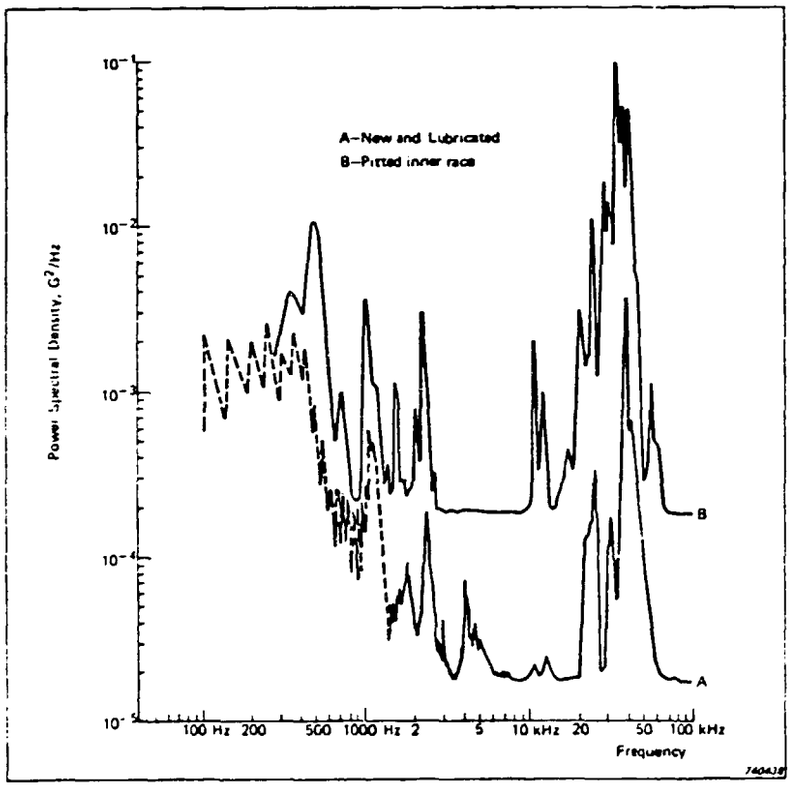

Fig. 6 Ball Bearing Vibration Spectra (Ref. 16)

Cepstrum Analysis

Since in a complex spectrum it may still be difficult to see the growth of sidebands by eye, and in particular to judge the relative importance of various modulating frequencies, this provides an application for "Cepstrum Analysis". In simple terms this is a method for detection of periodic components in a spectrum (eg. harmonics, sidebands) and consists in carrying out a frequency analysis of the (logarithmic or dB) power spectrum itself. The spectrum must be on a linear frequency scale with constant bandwidth. Reference (18) contains a detailed discussion of the basic concepts, methods of obtaining the cepstrum, and the application to gearbox fault diagnosis. Fig. 7 shows how the instruments from Fig. 4 can be used, while numerical (FFT) computation in a general purpose computer can alternatively be used (18).

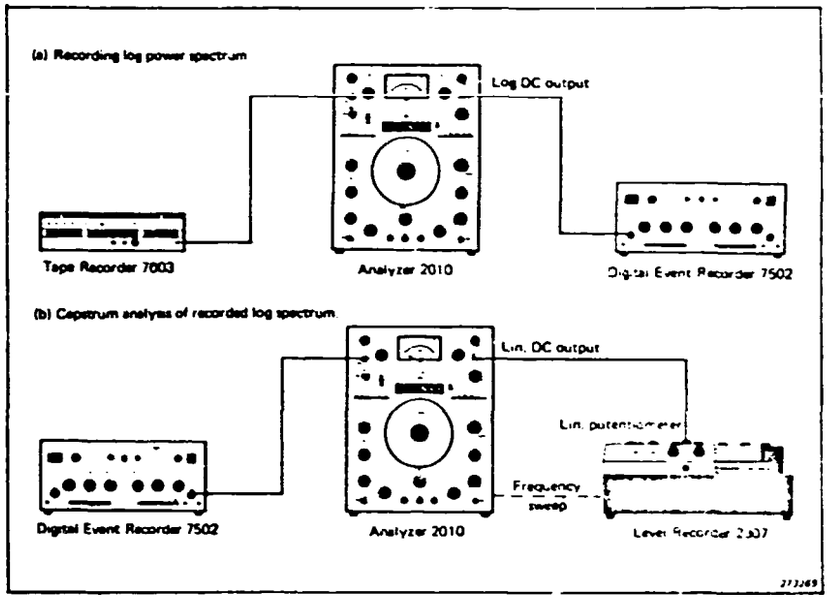

Fig. 7 Instrument Set-ups for Cepstrum Analysis

Example

The following example illustrates several of the concepts discussed. The measurements were made on a gearbox (mounted between a gas turbine and a generator) immediately prior to and shortly after a maintenance shutdown. The gearbox was primarily shut down to replace the internals, since fretting between the gearwheels and the shaft had been detected during an inspection 6 months earlier. The vibration signals before overhaul had also indicated misalignment, which was confirmed and corrected during the shutdown.

Fig. 8 shows 3% bandwidth analyses of the two signals compared as velocity, and it can be seen that the realignment has improved the VDI 2056 classification from "Just tolerable/Not permissible" to "Allowable", the overall RMS velocity being dominated by the components at the two shaft speeds (50 and 85 Hz).

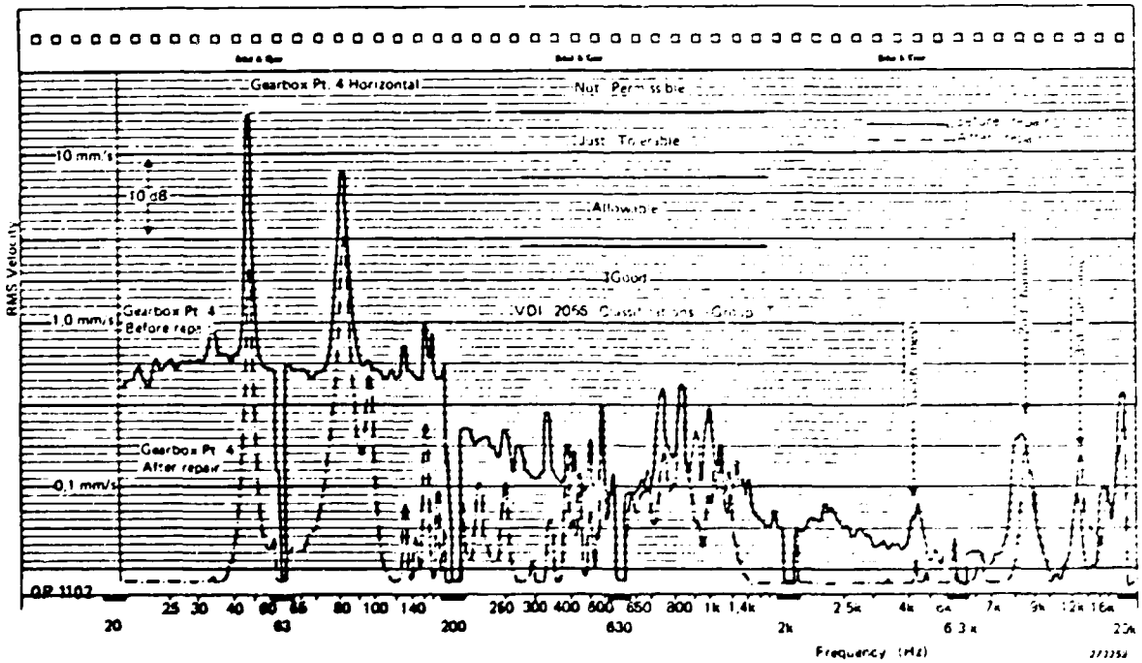

Fig. 8 3% Bandwidth Gearbox Vibration Spectra

It should be noted that the first signal "Before repair" was recorded as acceleration and integrated to velocity on playback. The noise level of the tape recording can clearly be seen, confirming that it is best to record the parameter with the flattest spectrum.

Another point of interest is that at the tooth meshing frequency and its harmonics it is difficult to determine from these 3% spectra that a significant change has occurred. The third harmonic has even risen in level slightly after repair. Fig. 9 shows constant bandwidth analyses of the same two signals on a linear frequency scale (this time as recorded since the overall slope of the spectrum is of secondary importance). The presence of sidebands around the tooth meshing frequency and its harmonics is now much more in evidence in the signal taken "Before repair", whereas the three harmonics stand out clearly "After repair". Fig. 10 shows cepstra corresponding to the spectra in Fig. 9 and this shows up the difference even more clearly and at the same time confirms that virtually all the modulation is occurring at the speed of the high-speed shaft (85 Hz).

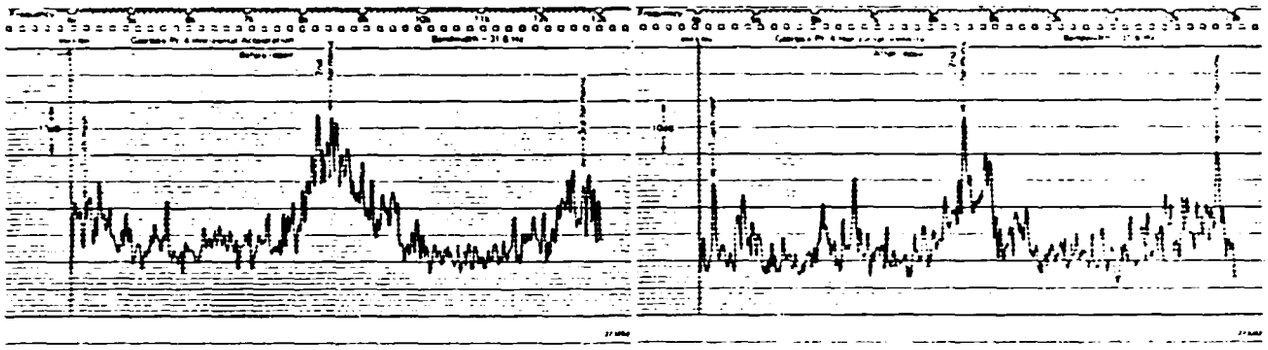

Fig. 9 Constant Bandwidth Gearbox Vibration Spectra

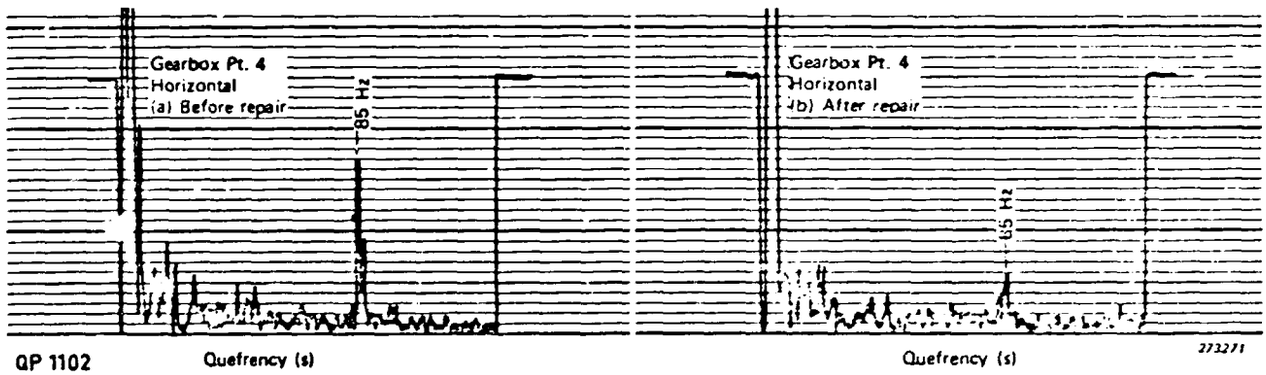

Fig. 10 Cepstra corresponding to Fig. 9

Time Domain Analysis

Spectral analysis, though very powerful, does not appear to be a universally applicable tool. For example, in the paper by Priede & Grover from Ref. (15) it is mentioned that with reciprocating machines, and in particular diesel engines, the vibration exciting forces tend to be impulsive in nature, thereby exciting the natural frequencies of the engine structure. Faults are therefore more likely to show up as changes in the various parts of the time signal rather than as a change in the spectrum (Fig. 11). The time signal also contains information on individual components (eg. particular gear teeth) which is averaged out in the frequency spectrum (13). A technique which can be useful in cases such as these is to overlay digitally the vibration signals from many machine cycles, triggering at the same point each time, and thus enhancing the regularly repeating phenomena with respect to random fluctuations (13, 14).

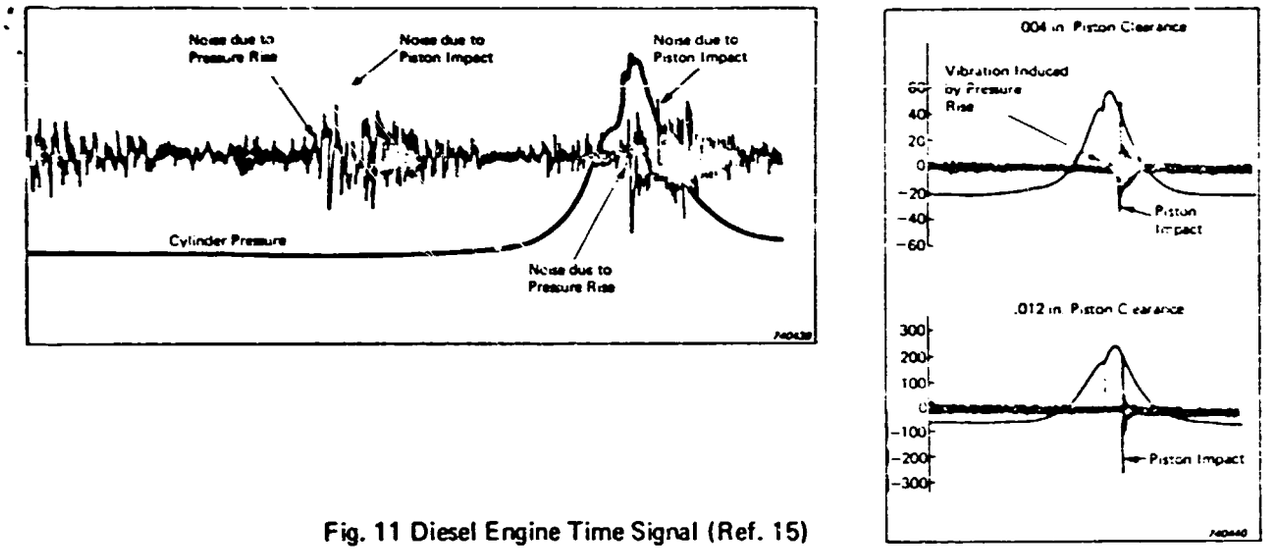

Fig. 11 Diesel Engine Time Signal (Ref. 15)

Data Handling

Where it is desired to monitor a large number of machines, it would be very time consuming to carry out visual comparison of the appropriate vibration characteristics (eg. spectra) and there will be considerable advantage in digital processing of the data. Real-time analyzers normally have the option of a digital output either to a computer or paper tape punch. It is also possible to obtain the spectrum in digital form from the high-speed analysis system shown in Fig. 4 by the addition of a Digital Encoder and Tape Punch (19). The analysis speed is then normally limited by the puncher and is thus as fast as when the output is obtained in this form from a real-time analyzer. One advantage of intermediate storage of data on paper tape is that it can provide a means of interfacing with large computers (eg. via a time-sharing terminal) with stringent requirements on data format. Where possible, however, considerable time can be saved by direct read-in of the data into the computer.

Ref. (19) gives one approach to the problem of programming for automatic spectrum comparison.

Other advantages of digital processing of spectra are:

(i) It is possible to carry out statistical analysis and thus obtain more valid information about trends, likelihood of failure etc. (Stewart (14)).
(ii) Cepstra can be calculated by an FFT program, possibly written in a high-level language such as Fortran (18).

It should be mentioned that with a suitable input-output device such as a Digital Event Recorder, a mini-computer with external storage (tape, disk, or drum) can be used to perform spectrum analysis by programmed FFT methods, plus all the other data processing mentioned. The main disadvantages are that programming would normally have to be in assembler language, and that programmed FFT is slow compared with hardware (typically 1 s).

PERMANENT MONITORING

Most permanent monitoring systems monitor a single quantity such as band-limited RMS velocity in the same way as a simple portable meter, and most of the same considerations apply. The main difference lies in the extremely high reliability required, and for example special consideration must be paid to ruggedness of cables, avoidance of noise pickup etc. Care must also be taken that the monitor does not give false alarms as a result of electrical mains transients, external mechanical shocks and suchlike. This can be achieved by requiring that the monitored level is outside the set limit for the whole of a set time delay. It is also desirable for the operator in the event of an alarm to be able to check quickly that the monitor is adjusted and functioning correctly.

Fig. 12 Industrial Vibration Monitor

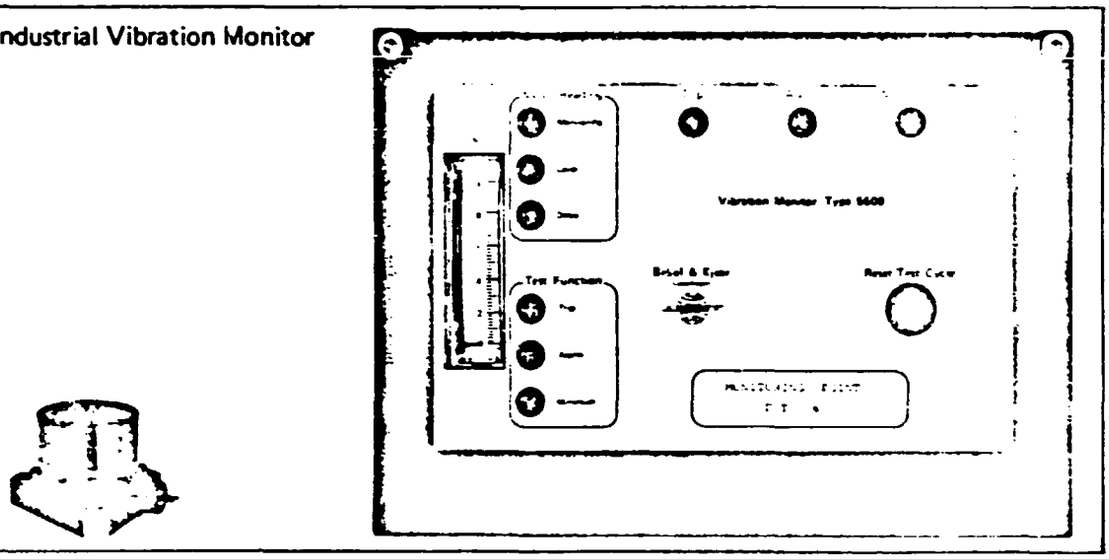

Fig. 12 shows a single channel monitor with many desirable features; a rugged waterproof housing, "Alarm", "Trip" and "Min. level" (indicates damage to pickup or cable) circuits each with time delay. All set levels and time delays can be adjusted (though not externally) and in fact the only external button initiates a checking sequence of the set levels and delays.

Continuous Spectrum Monitoring

For valuable complex machines which are crucial to the operation of a plant, it may be deemed justified to monitor the vibration spectrum continuously, thereby combining the advantages of both permanent monitoring and spectral analysis.

This can virtually only be done with a real-time analyzer, though in this case a 1/3-octave resolution may be considered adequate, if supplemented with a narrow band analysis facility for diagnosis of changes detected in the 1/3-octave spectrum.

Normally, to justify the use of an expensive real-time analyzer, it would have to be used for a number of monitoring points, perhaps several different machines. In this case it would be necessary to multiplex between the various input signals and apply different criteria for the evaluation of each spectrum, something which would almost inevitably require the use of a computer (minior micro). Introduction of a computer makes the use of a narrow band real-time analyzer feasible (since simple spectrum comparison is unlikely to be satisfactory (19)), and introduces many interesting possibilities. One such possibility envisaged in the foreseeable future is an operation in timesharing mode between fixed and regular calculations on a number of permanently connected channels, and intermittent operator-controlled calculations of various types. These could consist of special calculations (eg. cepstra) on the connected channels, or simple spectrum checking of additional signals recorded intermittently from a number of other machines, and brought to the console on a tape recorder.

CONCLUDING REMARKS

The latter system may seem a little far-fetched, but it could very easily become an economical proposition if it can be proved that incipient failure can be predicted with a high degree of certainty. It is believed that the state of the art is rapidly nearing this point.

Perhaps one of the main inhibiting factors in the past has been the lack of certainty in this respect. Plant operators have understandably been reluctant to invest large sums of money in instruments to determine whether the techniques described herein will work on their machines, and on the other hand the instrument manufacturers have not had much access to operating plant.

It is hoped that this paper indicates how it is possible to build up instrument systems from fairly modest beginnings, as experience is accumulated and the need for more sophistication makes itself apparent. It is also hoped that it (and the references) will help to avoid pitfalls which lead to faulty conclusions and thus can do a great deal of harm.

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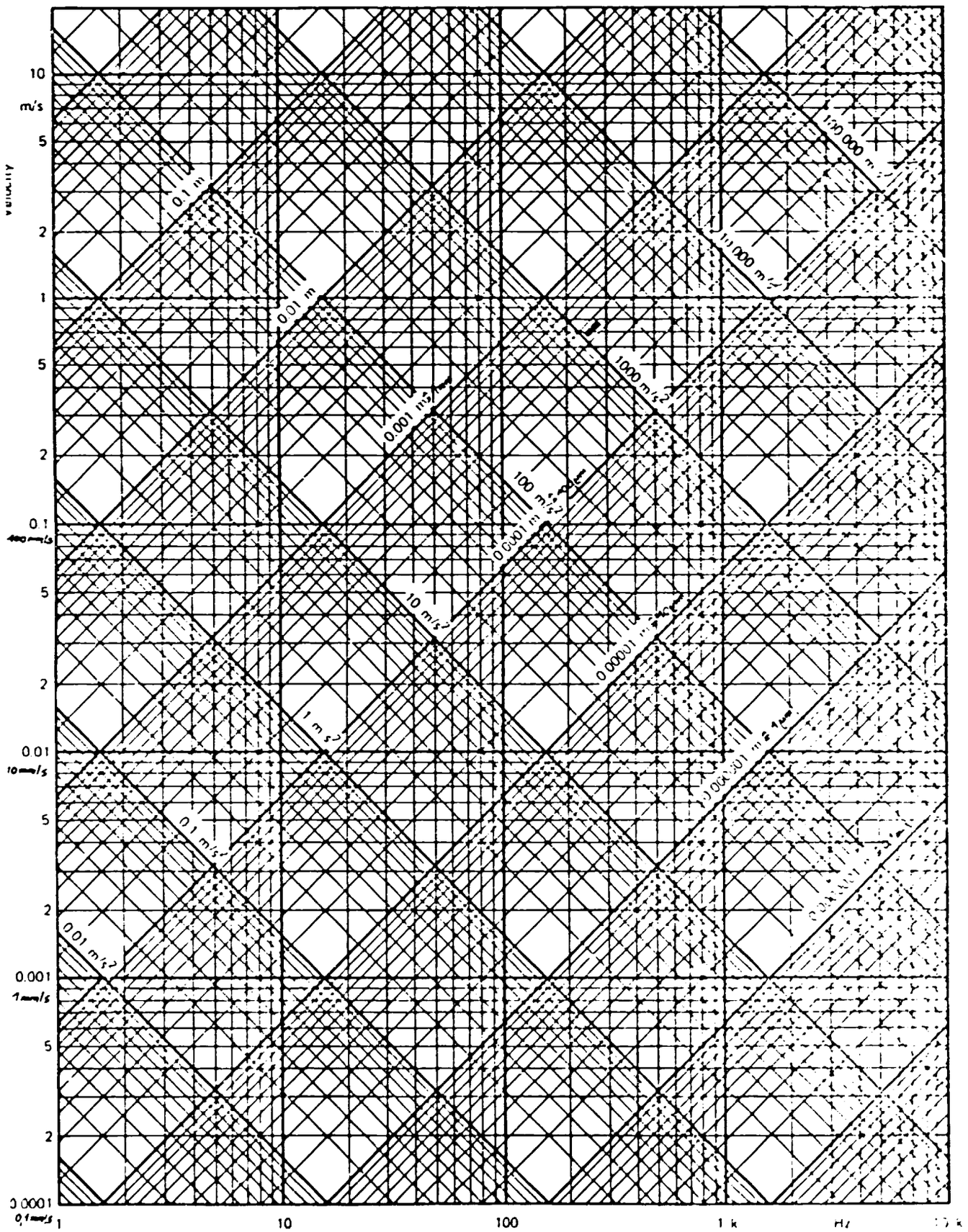
Frequency, acceleration, velocity, displacement nomograph (SI Units)



Velocity, Displacement and Acceleration, RMS values

Pipe Vibration Literature

by

P.W. Hope

In recent years there has been an ever increasing amount of attention paid to the behaviour of thin walled tubes under many varying conditions and environments. Such studies are of great importance to the oil and gas industries, and even greater importance to the rapidly expanding nuclear power industry where pipes and tubes have to withstand very high pressures.

One important topic for discussion is the Vibrations of the tube walls, which can be initiated in a number of ways, and if resonances are involved, can result in very significant effects. Housner (1) has reported an investigation carried out to determine the effects of high wind velocities on an oil pipeline crossing a dessert. He found that if the frequency of the forced vibrations due to the transport velocity of the fluid, coincided with the resonant frequencies of the pipe, amplification of the vibrations could be a significant factor in causing the pipe to buckle. Using a similar equation to that derived by Housner, S Naguleswaran and C.J. Williams (2), investigated the more specific problem of the vibrations in the tube walls, both theoretically, and experimentally. Since very high liquid transport velocities were found to be necessary to vibrate a metal pipe significantly a neoprene tube was used in their experiments, and the results extrapolated to apply to metal pipes. They also treated the case of pressure variations in the liquid contained in the tube when there was no transport velocity. The conclusions to be drawn from these investigations, were, that a flowing liquid in a metal pipe was not a significant factor in causing such pipes to vibrate and buckle, unless, very high flow velocites were involved, whichin the majority of engineering applications of stiff pipes has not been found to be the case.

Other investigators have come to similar conclusions, although in all the papers little mention has been made of the pressure variations in the tubes caused by pulsating flow. In an investigation carried out by S.S. Chen and also G.S. Rosenberg, (3) the effects of the coriolis force and curvature of the tube walls were evaluated these were found not to be significant at low fluid transport velocities. They did find, however, the existence of unstable oscillations of the tube walls when there was unsteady flow, and they also found that pulsating flow caused instability at relatively low transport velocities, they therefore concluded that this could be a problem of importance.

Other articles were also scanned, but as these were of an older date than the previous articles mentioned, no new informaiton was found. In particular T.B. Benjamin (4) in a lengthy expermential and theoretical paper summarizes the early work in this field and derives many of the basic equations used by the later workers.

Having noted these conclusions, it has been decided to investigate a number of tubes containing fluid without a transport velocity but with pressure variations set up in the liquid by artificial means; i.e., a vibration exciter.

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Detection of pressure variations in thin walled tubes by vibration measurements

by

Hans P. Olesen

Introduction

Fast pressure variations may seriously increase the fatigue loading of the tubes and other components of a piping system. Therefore, it is important to find a simple way to detect such variations and their distribution over the system. One promising method is to measure the extensional vibrations of the tube walls as the tube expands and contracts with the pressure variations. Naturally, care must be taken that other vibration modes are eliminated in the measurements.

The vibration due to pressure variations

Fig.1 displays the time varying internal pressure $p = p_o + p_1 \sin \omega t$ of a tube. Here p_o represents the nominal pressure and p_1 the amplitude of the pressure variations which have the frequency $f = \omega/2\pi$. These pressures force the tube to expand and to vibrate. Provided that the tube can be considered thin walled (wall thickness, $t < 0{,}1$ D, diameter) and that the wavelength of the pressure variations is much longer than the tube diameter the following simple expressions can be derived from the sketch of a tube cross section in Fig.2:

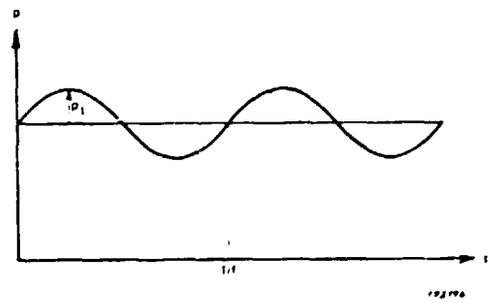

Fig.1.

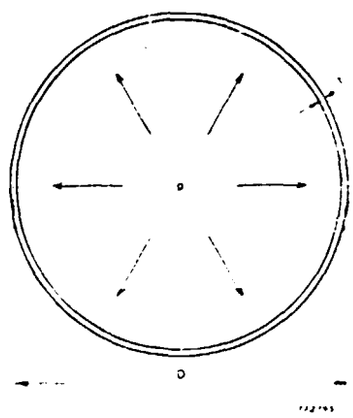

Fig.2.

As the static stresses and strains, introduced by the nominal pressure p_o, are irrelevant for derivation of the vibration values only dynamic stresses and strains are considered.

The pressure $p \sin \omega t = \overline{p_1} = \overline{p_2} + \overline{p_3}$ is balanced by the elastic and the inertial forces in the tube wall respectively.

The elastic stress in the tube wall is:

$$\delta = \frac{F}{A} = \frac{\overline{p_2}\, D\, 1}{2\, t\, i} = \frac{\overline{p_2}\, D}{2\, t} \qquad (1)$$

$$\text{and} \quad \delta = \epsilon\, E = \frac{\Delta p}{p} \quad E = \frac{\pi \Delta\, D}{\pi\, D} \quad E = \frac{\Delta\, D}{D} \quad E \Rightarrow \qquad (2)$$

$$\overline{p_2} = 2\, Et\, \frac{\Delta\, D}{D^2} = \frac{4\, Et}{D^2}\, d \qquad (3)$$

Where δ is the dynamic stress N/m^2

F is the unidirectional force developed against the tube wall [N]
A is the cross sectional area of material which must stand the force F [m^2]
D is the tube diameter (under nominal pressure) [m]
1 is an arbitrary length of tube [m]
t is the wall thickness (under nominal pressure) [m]
ϵ is the strain in the tube walls [dimensionless]
E is the modulus of elasticy for the tube material [N/m^2]
P is the tube perimeter [m]
d is the displacement of the tube wall [m]

The total force used to accelerate the tube material is:

$$F = \pi\, D1\, p_3 = ma = \pi\, Dt1\, \delta\, a \qquad (4)$$

$$\text{and} \quad \overline{p_2} = S\, \delta\, a \qquad (5)$$

where m is the mass of a length of the tube [kg]
δ is the mass density of the tube material [kg/m^3]
a is the acceleration of the tube wall [m/sec^2]
S is the volume of material [m^3]

If the additional pressure needed to accelerate some of the fluid in the tube is ignored, then the total pressuse p_1 can be found

$$\overline{p_1} = \overline{p_2} + \overline{p_3} = \frac{4\, Et}{D^2}\, d + t\, \delta\, a \qquad (6)$$

As displacement and acceleration, at a given frequency, are related by $-\omega^2$ the expression can be changed to:

$$\overline{p_1} = + \left[\delta - \frac{4\, E}{D^2\, \omega^2}\right] ta \qquad (7)$$

$$\text{or} \quad \overline{p_1} = \left[\frac{4\,E}{D^2} - \omega^2\right] \text{td} \qquad (8)$$

Both these expressions show that resonance occurs when

$$\delta = \frac{4\,E}{D^2\,\omega^2} - \qquad (9)$$

$$\text{or} \quad \omega = \sqrt{\frac{4\,E}{D^2\,\delta}} = 2\,\pi\,f_o \qquad (10)$$

At this frequency a very little varying pressure produces large accelerations (and displacements). The resonant frequency is reduced when the tube carries heavy fluids, and its value is slightly increased by the bending effect which occurs when the wavelength is not long compared to the tube diameter

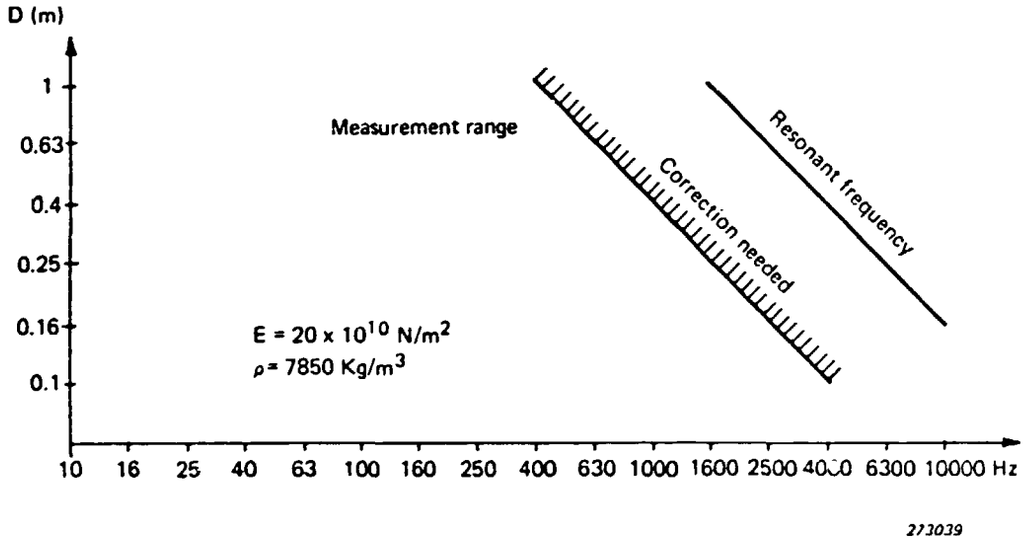

Fig.3.

The most interesting frequencies, however, are below the resonant frequency and, therefore the pressure may be determined by the last term of equation 7 or the first term of equation 8 up to approximately 1/4 f_o. The useful measuring range for tubes of varying diameters is illustrated in Fig.3.

$$\overline{p_1} \cong - \frac{4\,Et}{D^2\,\omega^2}\,a = \frac{4\,Et}{D^2}\,d \qquad (11)$$

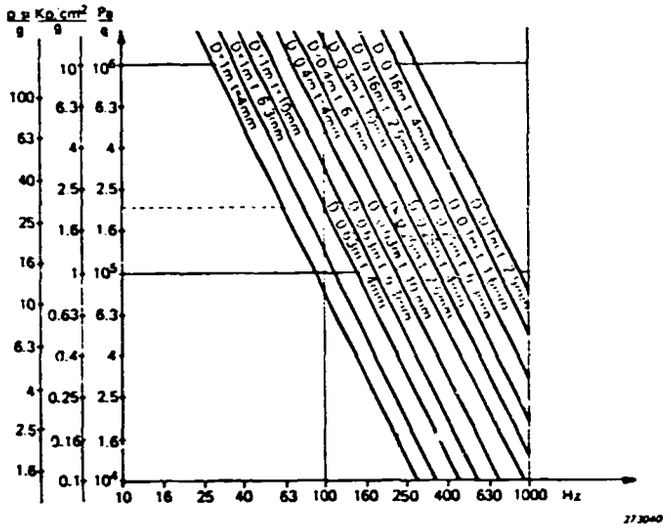

Fig.4.

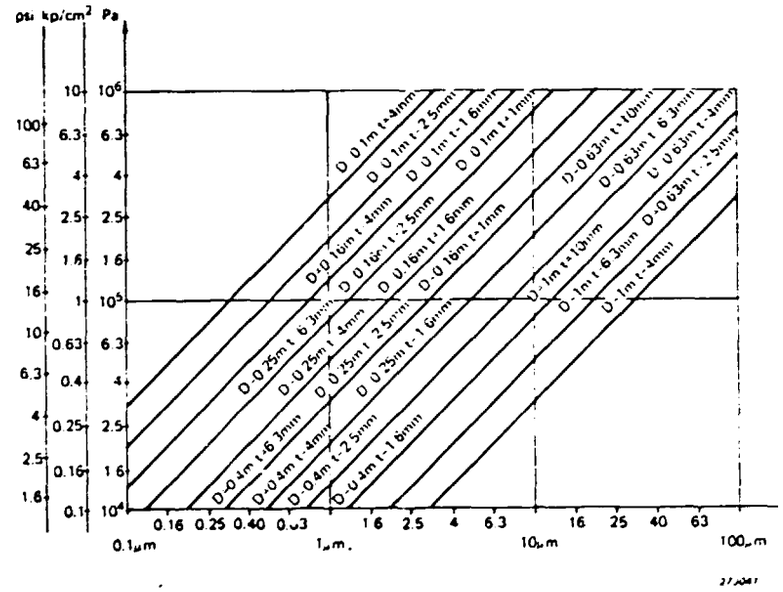

Fig.5.

The acceleration-to-pressure conversion is shown as a function of frequency for different tube configurations in Fig.4, and the displacement-to-pressure conversion is plotted in Fig.5.

The generation of pressure variations

The pressure variations are often produced in the pumps of the system and they will, therefore, often be largest near the pumps. However, the geometrical configurations of the piping system may, in some cases, allow longitudinal resonances in the fluid near the pump frequencies. Thereby, even weak pressure fluctuations may be amplified to significant values. In long, uniform lengths of tube, the pressure variations may be the same along the tube length, as indicated in Fig.6a. However, most often the tube has a bend or some other reflecting structure which causes standing pressure waves which vibrate some parts of the tube more than others. (see Fig.6b).

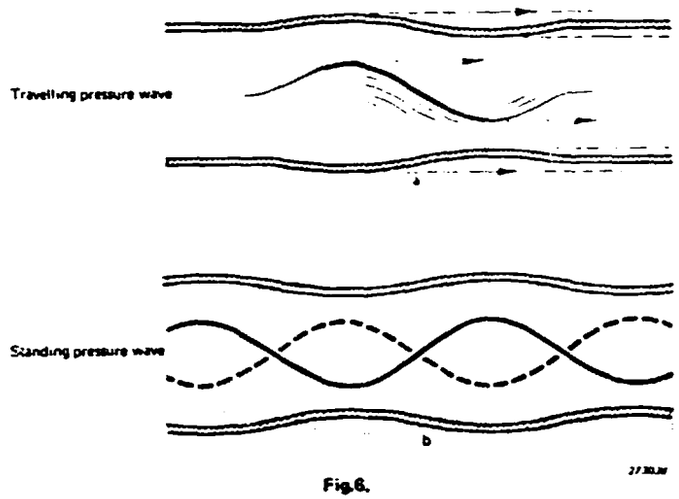

Fig.6.

Practical measurement of pressure variations

The tubes of a piping system may be excited into other vibration modes than the extensional mode which is caused by pressure variations. Often the tubes vibrate in bending as well as in extension. However, the frequencies of the two modes may not be the same and the two modes may be separated after a frequency analysis has been taken at a given point.

The frequency analysis can be carried out with a simple portable system such as the one shown in Fig.7, or a more sophisticated system (shown in Fig.8) can be used, whereby, automatic recording is performed (see example of recording in Fig.9).

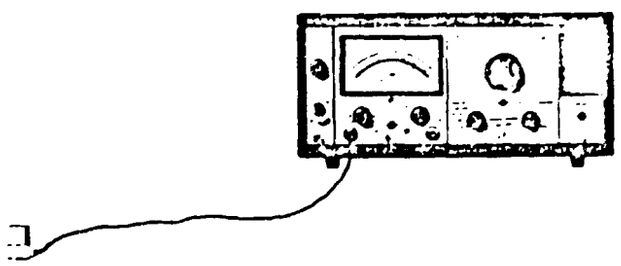

Fig.7.

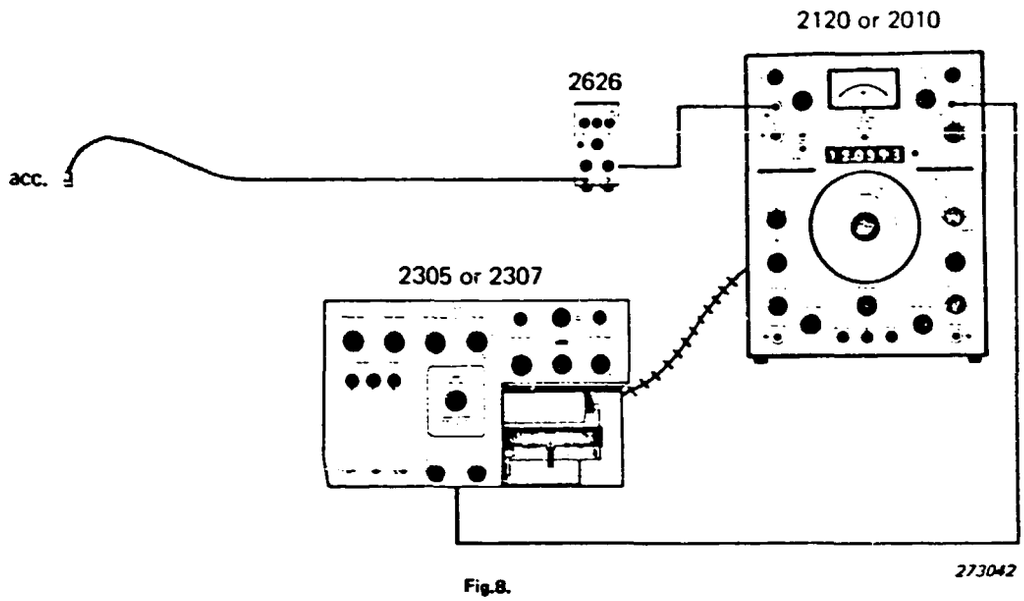

Fig.8.

At the frequency of each vibration peak of Fig.9, a number of measurements are taken on the tube perimeter. As shown in Fig.10a extensional vibration (pressure variations) result in almost equal signal levels at different measurement points while bending vibration produces the highest levels in the axis of vibration (Fig.10b).

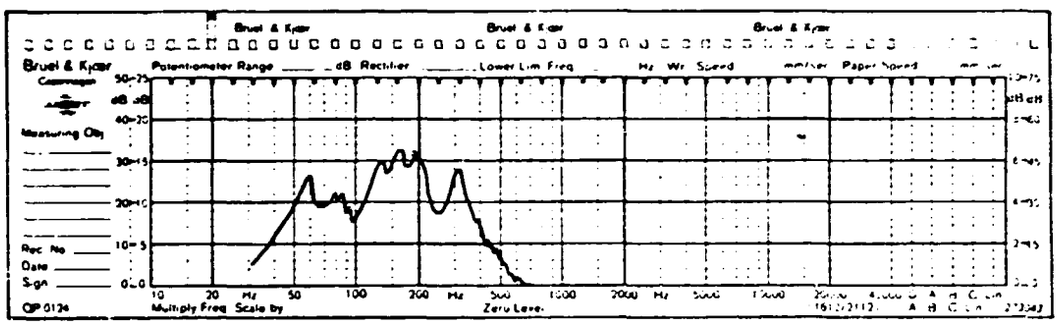

Fig.9.

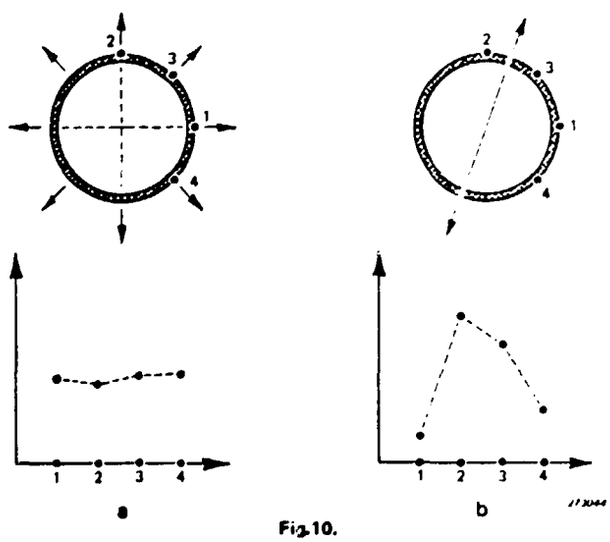

Fig.10.

From Figs.4 and 5 it may seem that displacement measurements were simpler than acceleration measurements. This is normally not the case, as displacement transducers are more inconvenient to use in the field than accelerometers. The displacement value can, naturally, be obtained by integration of the acceleration signal, but due to the small displacement which can be expected, acceleration measurements are recommended.

Example

In a practical measurement 7,2, 4,8 and 2,4 g was measured at 230 Hz on three tubes respectively, with diameter D = 0,3 m and wall thickness t = 5 mm. In Fig.7 a vertical line is drawn at 230 Hz to cross the tube lines. For the tube in question the tube line must be drawn as shown in the figure, yielding approximately $2,10^5$ N/m^2 per g. This indicates pressure variations of $14,4 \cdot 10^5$, $9,6 \cdot 10^5$ and $4,8 \cdot 10^5$ N/m^2 respectively or 14,4, 9,6 and 4,8 kp/cm^2 or 202, 136, and 68 psi.

Conclusion

Vibration measurements in combination with frequency analysis may be a very useful tool when the distribution of pressure variation in a piping system must be determined. A detailed mapping of the measuring results is essential for investigation of geometries which cause standing pressure waves and, thereby, in many cases reduce the safety factor built into the system and, consequently, the plant efficiency.

Furthermore, after the "normal" vibration pattern has been thoroughly investigated, regular checks or continuous monitoring may be introduced, to reveal changes in material properties with time due to fatigue loading.

4. UNIDO-Workshop

Department for Testing Materials in Chemical Industry - Scope of Work

The work of a department for testing materials can be described as follows:

1. The department is reponsible for all materials which are used in the plant on vessels, pipelines, engines, structures.
2. It has to secure that the right material is supplied for a given process or service conditions.
3. It has to control the vessels and installations in service in view of damages, suggest measures to avoid such damages.
4. It has to secure, that construction and maintenance work is done properly in view of the applied material and the service conditions.

Materials used in chemical industry:

1. Most widely used are the metallic materials
   a) Within this group iron and steel and its alloys have the broadest application, for instance:
   Carbon steel, cast iron,
   steels for boilers and heat exchangers, where no or only small corrosion is to be feared;
   steels for low-temperature service;
   stainless steels, ferritic and austenitic, for corrosive environments;
   steels for high-temperature service;
   steels, resistant against attack by hydrogen, and so on.

./2

b) Nickel and its alloys, for instance, nickel-molybdanium-alloys of the Hastelloy-type and nickel-chromium-alloys of the Incoloy- and Inconel-group, for corrossive environments or high-temperature service, nickel-copper-alloys in plants for water treatment.

c) Copper an copper alloys
These materials are not as far used, as the above mentioned. For instance, heat exchangers in the oilsystems of turbines and compressors are made of these materials.

d) Aluminium and its alloys, mainly for storage-tanks and pipelines for not to corrosive media.

e) Lead is not used any more on a wider scale, one will find them in some parts of sulphuric acid plants.

2. Non metallic materials

a) Enameled vessels, valves and pipes for high corrosive service or where high purity of the product is demanded, i. e. in the pharmaceutical industry.

b) Rubber lined vessels
Natural and synthetic rubber is a very good corrosion-resistant material, which can be used in a rather wide range at ambient or slightly elevated temperatures, i. e. up to 80 degrees centigr. at the utmost.

c) Thermoplastics, for instance polypropylene, polyethylene or others, have as nearly all organic materials a temperature limit of application.

d) Fluorinated plastics, as Teflon and Viton, which have a high corrosion resistance and a high temperature limit.

e) Resines-phenolic, epoxydes e.t.c.-, which can be used as corrosion-, or weather-resistant overlays on the inside andoutside of tanks, vessels, even heat exchangers.

To deal with materials successfully the expert has to know

the chemical composition
the metallographical structure,
the mechanical values,
the influences - mechanical, thermal, chemical - upon the material under service conditions.

Therefore we have in our department three main kinds of tasks:

1. mechanical and metallurgical,
2. non-destructive testing,
3. chemical, that is on the field of corrosion.

For the abcve mentioned problems it is necessary to use a certain range of investigations.

1. Identification of materials:
   At repaire and maintenance of engines it can become necessary to replace damaged pieces, for instance bolts, small axles e.t.c., the material of which is unknown. Therefore one has to make some identification tests: hardness, metallographic structure, tensile- and yield-strength.
   That kind of tests has also to be done, when there is no connection between the delivered material and the certificates of the manufacturer.

2. Investigation of damages:
   Here the visual investigation of the damaged parts under a binocular microskope is one of the most importand methodes. For instance in case of rupture the

operator can find out, wether fatigue of the material, corrosion or mechanical force initiated the cracking of a piece under investigation.

3. Non destructive testing:-
Non destructive testing is mainly applied as a control of construction and repair work, that means control of the welding. It is also used for detecting failures in the material, as sheets, pipes, castings, etc.
Such defects may be cracks, slags, piping in castings, e.t.c.
In the case of welding-control the investigations have to assure the welding has been done properly, that there are no unduly big and many pores, slags and no cracks.

The methodes in this field are:

radiography, X-rays or radio-isotopes,
ultrasonic measurementes,
crack detection by magnetic methode or dye penetrant,
control of temperature in case of heat treatment - preheating and post weld heat treatment.

4. Corrosion:
Control of vessels running under severe conditions by means of visuel investigation, ultrasonic measurements, control coupons, which are installed inside the vessels.
Selection of the right material for given process-conditions by tests in the laboratory or with coupons in the vessels.

It must be pointed out however, that none of the above mentioned methodes can be used single, but it is necessary to apply two or more methodes to cleare a case. Therefore the expert in material investigation has to keep in mind all these possibilities.

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Further the material testing department has to make proposals upon the application of materials in new installations or plants, upon issuing standards for material quality, welding procedures, control and investigation-work.

As manifold as the work to be done is, as manifold is the equipment.

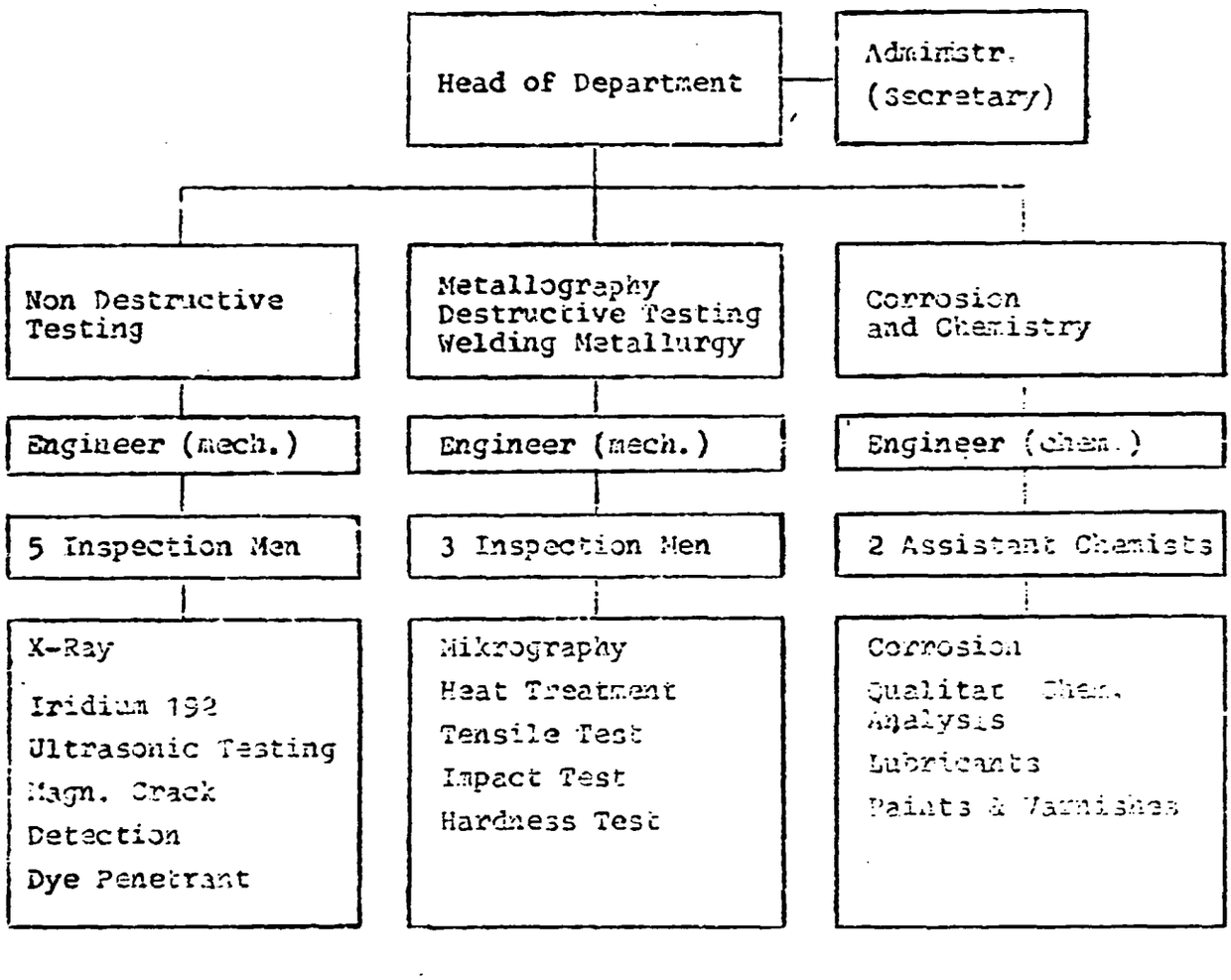
1. Mechanical and metallurgical testing
   Here our department can do the following investigations and tests:
   a) Measure of yield- and tensile-strength by a testing machine with a load of 20 tons.
   b) Measure of hardness by two hardness-testers one for Vickers (H_V) and one for Brinell (H_B).
   The Vickers-tester works with a diamond, shaped like a pyramid with a quadratic base, which is impressed in to the surface of the material.
   Whereas the Brinell-tester works by means of a sphere made of hardenedsteel. One gets on impression in the form of a circle
   c) Measure of impact-strength.
   d) For metallographical work we have grinding and polishing devices, to manufacture test pieces, which are to by investigated under a metal microscope.
   e) A binocular microscope for visuel investigation of damaged pieces of equipment.

2. Non destructive testing
   a) Radiography
   For this hind of work we have 2 apparates for X-ray with 160, and 240 kilovolts respectively, as well as 3 apparates with radio-isotopes. We use Iridium 192.

3. In the field of corrosion there is the usual laboratory equipment. But as already told, we do much investigation work by control coupons in the vessels, which method gives better results, as the coupons are tested directly under service conditions.

(Verbaul)

Organisation of the Department for Testing Materials



Equipment for Non Destructive-Testing

ame of Equipment	Producer Name and Adress	Purchase- Price ÖS	
ndustrie-Röntgeneinheit "Eresco" 160 kV/5 mA resco Directional Radiating Unit 160 kV/5 mA and resco Directional Radiating Unit 240 kV/5 mA	Rich. Seifert & Co Röntgenwerke Bogenstraße 41 D-2070 Ahrensburg *)	181.000,- (1965)	
ammaradiographie-Anlage "Gammamat TI" amma-Radiographic Equipment "Gammamat TI"	Sauervein GmbH *) Postfach 150088 D-4000 Düsseldorf 1	70.900,- (1974)	40 Ci Ir 192
ammaradiographiegerät "Teletron SU 100 A" amma-Radiographic Equipment "Teletron SU 100 A"	Nuclear GmbH Florastraße 16 D-4000 Düsseldorf 1	86.900,- (1976)	100 Ci Ir 192
osisleistungswarngerät "Gammatest 1" ose Rate Alarm "Gammatest 1"	Graetz Vertriebsgesell- schaft mbH Postfach 294 D-5990 Altena 1 *)		
osisleistungsmeßgerät "X 50 B" se Rate Meter "X 50 B"	Graetz *)	15.100,- (1978)	
osisleistungsmeßgerät "EMB 3" ose Rate Meter "EMB 3"	Landis & Gyr Breitenfurter Straße 148 a 1230 Wien	15.100,- (1978)	
igital-Wanddickemeßgerät "DM 1" und "DM 2" ltrasonic Wall Thickness Gauge "DM 1" and "DM 2"	Krautkrämer GmbH *) Luxemburger Straße 449 D-5000 Köln/Klettenberg	46.700,- (1978)	
ltraschallgerät "USM 2" ltrasonic Flaw Detector "USM 2	Krautkrämer GmbH *)	63.000,- (1974)	
pulsschallgerät "USIP 10" ltrasonic Flaw Detector "USIP 10"	Krautkrämer GmbH *)	128.100,- (1959)	
tatiflux or Nondestructive Electrified Inspection	Magnaflux Corporation 7300 West Lawrence Avenue Chicago 31, Illinois	3.700,- (1971)	
andmagnetflux-Gerät inchom Sempun Flaw Detector	R.P.R. Patents LTD. Alexandra Palace Station London 10	8.000,- (1958)	
eprüfgerät "Equotip" ardness Tester "Equotip"	Proceg SA Riesenbachstraße 57 CH-8034 Zürich Switzerland	29.700,- (1979)	
ragbares magnet.-elektr. Rißprüfgerät iede "TWM 42" agneto-electric Crack Tester Tiede "TWM 42"	Tiede KG Bahnhofstraße 96 D-7081 Essingen	29.000,- (1974)	

*) Vendor for Austria: Mittli KG
Hegergasse 7
1030 Wien

Name of Equipment	Producer Name and Adress	Purchase Price ÖS
Härteprüfgerät nach Vickers Hardness testing machine "Vickers"	Wolpert-Werke GmbH *) Kopernikusstraße 11 D-6700 Ludwigshafen	ca. 350.000,- (1941)
Härteprüfgerät nach Brinell Hardness testing machine "Brinell"	" "	ca. 300.000,- (1941)
Schlaghärteprüfgerät "Equotip" Portable hardness tester (digital reading)	Gebrüder Bach GmbH Oswald Redlich Straße 5 A-1217 Wien	30.000,- (1979)
Kleinlasthärteprüfer "Durimet 2" Hardness tester (small load instrument)	Leitz-Austria Postfach 62 Dr. Karl Lueger Ring 12 A-1014 Wien	128.800,- (1980)
Zerreißmaschine Tensile testing machine	Wolpert-Werke GmbH *) Kopernikusstraße 11 D-6700 Ludwigshafen	ca. 1,000.000,- (1941)
Pendelschlagwerk PSW 30 Impact strength testing machine	Mohr & Federhaff & Losenhausen Prüf- und Meßsysteme GmbH Postfach 1502 D 68 Mannheim 1	95.000,- (1975)
Techno-Endoskope, Modell D 2 e Technical-Endoscope	Deutsche Endoskopbau-Gesellschaft Sass, Wolf & Co mbH Ritterstraße 12 D Berlin	15.991,- (1959)
Technisches Endoskope "TeKZ 5000/S" Technical-Endoscope	Technokontroll AG **) Imbisbühlstraße 144 CH-8049 Zürich	53.000,- (1978)
Gleichspannungs-Porenprüfgerät Poroskope, Type H 3 d "Poroskope"-direct voltage tester for pores	Fischer GmbH & Co Postfach 4 D-7032 Sindelfingen 6	30.000,- (1974)
Schichtdickenmesser "Diameter", Type SM 1b Overlay thickness measuring instrument	List-Magnetik Viehweg 17 - 19 D-7022 Leinfelden	4.000,- (1973)
Mettler-Makro-Analysenwaage H 10 W Analytical balance "Mettler H 10 W"	Comesa KG Tegethoffstraße 26 - 28 A-4020 Linz	9.601,- (1970)
Mettler Präzisionswaage PC 4400/19 Precision balance "Mettler PC 4400/19"	" "	25.300,- (1980)

*) Vendor for Austria: Otto Dohmen
Argentinierstraße 42
A-1041 Wien

**) " " " Eichler KG
Pernerstorfergasse 5
A-1101 Wien

4. UNIDO-Workshop

Stress Analysis of Piping System

Basic steps of calculation:

1. Procedure of design starts with making a freehand isometric piping-sketch.

2. Spot preliminary locations of hanger or supports, locate hangers at or near any concentrated loads (heavy valves, risers .....)
   Pick up all horizontal bends, to prevent any excessive overhang.
   Hanger spacing must be close enough, to prevent excessive sagging.

3. Study building steel

4. Check for interference (pipes, constructions)

5. Calculate distribution of weight
   important to obtain zero load at equipment flange

6. Summarize hanger loadings

7. Calculate distribution of expansions to hanger

8. Calculate distribution of equipment movement

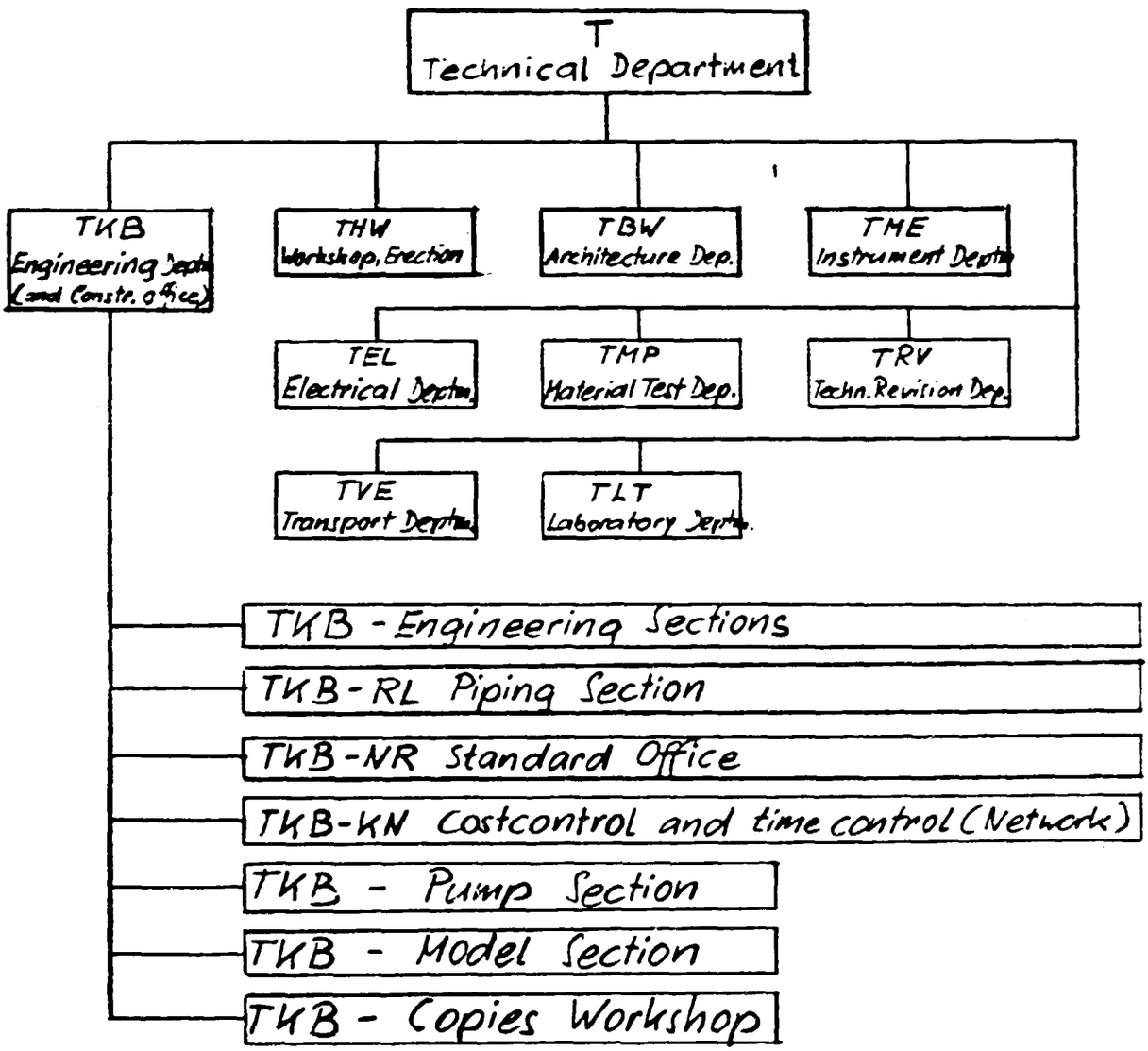
9. Summarize movements

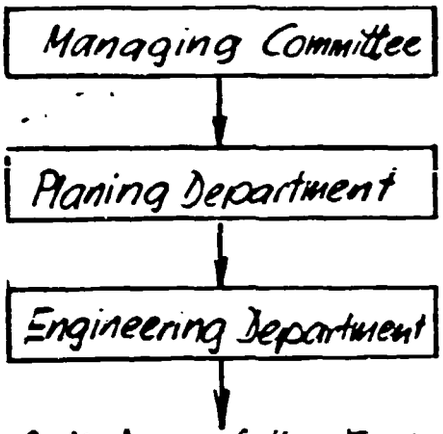
10. Choose hangers or supports for loadings and movements

4. UNIDO-Workshop

The Engineering Department of Chemie Linz A.G.

is a section of the Technical Department (T).





Activity of the Engineering Department:

Basis Engineering

Design Basis (see CO_2-Liquefy)
Basis datas of the process (e.g. Melamine or Urea-Fibel)
Process Flow Diagram (see CO_2-Liquefy)
Material balance
Plot plan
Process P and I-Diagram
Time schedule (CO_2-Liquefy and Urea plant)
Project medium key
Description of the plant
List of motors and
Specifications for the machines and apparatuses (e.g. V-340)
Specifications for the instruments
Data sheets (A1B6)
Cost estimation for the project

Detail Engineering

P and I-Flow Diagram (see CO_2-Liquefy and Instrument symbo
Quotation for machines, apparatuses, piper etc.
Orders
Plant model
Pipework isometrics
Measuring and regulation (control) diagram
Checking of the orders
Checking of the workshop drawings
Orders for the erection
Manuel handbook
Commissioning and testrun
Control of the project cost and control of the time schedule
(e.g. Melamine plant, Urea plant)

Instrument symbols
Meßstellen – Symbole

Kurzbezeichnungen short sign

Ausführung:

installed at the apparatus **Für örtliche Messungen**	installed at control plate or **Für Einbau in Meßtafel od. Meßwarte** control room
	
	

Die Buchstaben bedeuten:

	at first position an erster Stelle	at second pos. an zweiter Stelle	at third or next pos. an dritter od. höherer Stelle
A	Analyse *analyses*	Alarm *alarm*	Alarm *alarm*
C	Leitfähigkeit *conductin*	Regler *controller*	Regler *controller*
D	Dichte *specific gravity*	—	—
E	—	Element	—
F	Fluß *flow rate*	—	—
G	—	Glas *glass*	—
H	Fernbedienung durch Hand *remote control by hand*		
I	—	Anzeiger *indicator*	Anzeiger
L	Stand *level*	—	—
M	Feuchtigkeit *moisture*	—	—
P	Druck *pressure*	—	—
R	—	Schreiber *writer*	—
S	*number of* Drehzahl *revolutions*	Schaltung *circuit*	Schaltung
T	Temperatur	—	—
V	Viskosität *viscosity*	—	Ventil
W	Gewicht *weight*	Hülse *shell*	—

Weitere Buchstaben

d	Differenz	AH	Alarm hoch *high*
h	mech. Thermometer	AL	Alarm tief *low*
r	Verhältnis *proportion*		
pH	pH-Wert		
Q	Zähler *counter*		

Hier nicht definierte Messungen siehe ISA Standard S. 51 Ausg. 1968

1973 11 05

Scope of Supply for extended basic engineering

The following documents will be supplied according to a time schedule to be agreed upon for the procurement, construction and acceptance of the plant and its elements. All documents will be kept up to date and will be elaborated in German (perhaps English) language according to the metric system (international system of units according to DIN 1 301). Symbols or designations shall correspond to the Chemie Linz AG standards, to Austrian standards or DIN standards resp. to the Chemie-Linz AG short designations. Documents will be submitted in the form of copies and one reproducible copy each.

a) Process Flow Diagram with quantities of the materials and their composition within the different phases of the process, operating data, thermal balance, consumption of raw materials and energy as well as yields. Above data will be indicated for minimum, normal and maximum throuput. Description of the process.

b) Draft layout indicating platform loads (forces, weights and moments) and ceiling break-throughs, according to which construction drawings can be prepared. Final installation drawings, foundation drawings, pipe bridge drawings indicating weights, forces and moments.

c) Piping and Instrument Flow Diagram with all process and energy pipe networks comprising all machines, apparatus, fittings as well as measuring and regulating equipment. The diagram will be established in such a way that the relation between process flow diagram, installation dravings, model, isometrics and measuring and regulating

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c) continued

diagram will be clearly shown. As far as possible the dimensions and levels of apparatus and machinery will be shown according to scale. Material data lists, media codes, classifications for pipework, fittings and seals.

d) Specifications (descriptions and dimensional sketches, data for the pipe connecting sockets, i. e. quantity, nominal widths and nominal pressure, material, static and dynamic loads, permissible pressure loss, amounts of heat, temperature, pressure and the like) for all machines and apparatus including required steel structures therefor, if any, to permit relevant design drawings to be prepared and/or the equipment to be built. Workshop drawings with parts lists or equivalent documents with apparatus data or apparatus details for equipment which require special design.

e) Plant model in a scale of 1 : 25 (details possibly 1 : 10) consisting of structural framework with stairs, platforms and ladders, all apparatus and machines, pipe bridges, process and energy pipework, main routing of measuring and regulating lines as well as of electric cables.

f) Pipework isometrics with parts lists for all pipelines with fitting lengths in all three levels. Indication of sliding and fixed points and/or determination of pipe supports indicating static and dynamic values as far as they have to be specified by the engineering company. Determination of pipe connecting sockets on the apparatus in plan form with level indication. Provisional list of materials at the beginning of planning for the complete pipework including fittings and accessories. Specifications for special pipe material not yet included in the documents of Chemie Linz AG.

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g) Specifications for insulation and painting of machines, apparatus, pipework and steel structures.

h) Measuring and regulating (control) diagram with specification list for the measuring and control devices with indication of nominal values, measuring and regulating (control) range and relevant permissible deviations, information on material coming in contact with the media as well as indication of physical values (pressure, temperature, density, viscosity etc.) , safety settings for the regulating and/or control fittings, interlock diagram and alarms for the instrumentation of process engineering. This documentation must be detailed enough to permit ordering of the corresponding equipment items.

i) Specification of electro-technical equipment.
Draft of distribution system (one-line diagram), provisional motor list, power mains and lighting facilities. Summary of critical points in regard to explosion proofing (drawing of explosion hazard zones), control and interlock diagram and alarms.

j) Checking of our dravings and of technical order specifications for all plant equipment from the process engineering point -of-viev.

k) Description of the plant, start-up and operating instructions, control and analysis procedures.

l) Commissioning and test run by competent persons of the engineering company.

Time-table for the delivery of the particulars for an enlarged Basic Engineering

	months
Process Flow Diagram and process description	.....
Draft layout with vaste gas- and vaste vater particulars	.....
Final installation drawing 1 month after receiving the last particulars	.....
Simple Piping and Instrument Flow Diagram (Process-P and I-Diagram)	.....
Piping and Instrument Flow Diagram (P and I-Diagram)	.....
Media codes, classifications for pipework, fittings and seals	.....
Provisional list of materials for the complete pipe material	.....
Specifications for equipments with longer terms of delivery (reactors, compressors, etc.)	.....
Specifications for equipment with the shortest terms of delivery	.....
Plant model	.....
Pipework isometrics with parts lists	.....
Specifications of the measuring and regulating devices	.....
Provisional motor list	.....
Draft of the electric-distribution systems	.....
Plan for explosion- and hazard zones	.....
Control and interlock diagram and alarms	.....
Start-up and operating instructions (Operating instruction book)	.....

TKH/As/La Herr Aschauer 1980 01 14

Auslegungsdaten (Design-Basis) für
die CO2-Verflüssigungsanlage Bau 219 (CO_2-liquefy)
Proj. Nr. 1499/APA

1. Standort der Anlage: (location of the plant)

1.1. Standort: Werksgelände Chemie Linz AG, nördlich Single-Train-Anlage. Bau Nr. 219.

1.2. Höhenlage über Normal-Null (NN). Werkshöhe ± 0,0 m = Straße = 254,43 m über Adria. (base line altitude over the see (Adria))

2. Klimatische Verhältnisse: (climate)

2.1. Niederschläge:

(Rain) Regen: max. 180 l/ha sec. während 15 min
Regendichte: max. 26,5 mm/h während 20 min

(Snow) Schneefall: max. 17 cm/Tag (Snowheigh)
Schneelast: max. 75 kg/m2 (Snowload)

2.2. Lufttemperatur: (air temp.)
mittlere Temperatur im Jahresmittel: +10° C
wärmster Monat: Juli, max. Temp.: +35° C
kältester Monat: Jänner, min. Temp.: -20° C
Tagesdurchschnittstemperatur (über 24 Std.)
im Sommer max. +27° C
im Winter min. -14° C

2.3. Relative Luftfeuchtigkeit: (moisture of the air)
maximal 100 %
im Mittel 72 %
minimal 18 %

2.4. Wind und Luftdruck: (wind and air pressure)

2.4.1. Hauptwindrichtungen (Angaben in % aus Richtung)

33,1 % NW	18,4 % W	2,3 % SW	4,4 % S
17,8 % SO	8,2 % O	8,7 % NO	6,9 % N

2.4.2. Art der Umgebungsluft:- Industrieluft

2.4.3. Windgeschwindigkeit und Staudruck gestaffelt nach Höhe: (wind velocity)
0 - 6 m: Vmax. = 28,2 m/s q max. = 50 kg/m2
6 - 8 m: " = 32,2 m/s q max. = 65 kg/m2

Änderungen: a) 1980 05 23
b) 1980 08 19 hv

T.12

CHEMIE LINZ AG

Auslegungsdaten (Proj. Nr. 1499/APA)

0 – 20 m: Vmax. = 35,8 m/s q max. = 80 kg/m2
20 – 100 m: Vmax. = 42,0 m/s q max. = 110 kg/m2
Windgeschwindigkeit Durchschnitt: 2,5 m/s

2.4.4. Luftdruck: (air pressure)
Tagesdurchschnitt der letzten 5 Jahre.
normal: 738 mm Hg
minimal: 708 mm Hg
maximal: 755 mm Hg

2.4.5. Zulässige Luftverunreinigungen: (max. emmissions)
Gem. MAK-Werte und von Kommissionierung (Behörde) abhängig.

2.5. Grundwasserspiegel: (underground water)
Höchststand ca. 249,00 m über NN
Überschwemmungsgefahr bei HW 100 = 253,14 m (bei Steyreggerbrücke)

2.6. Bodenfrostgrenze: (frostpoint)
0,30 m unter Geländehöhe (under ground)

3. Bautechnische Grundlagen: (architecture basis)

3.1. Höhenbezugsmaß: ± 0,00 m = 254,43 m über NN
Alle Höhenangaben sind auf ± 0,00 m zu beziehen.

3.2. Bauhöhenbeschränkung: keine

3.3. Freie Durchgangshöhe unter den Rohrbrücken (freebord under piperackes) sind 5,0 m (teilweise 4,50 m vorhanden)

3.4. Erdbeben nach ÖNORM B4015 (earthquake force)

3.5. Zulässige Bodenpressung: 1,8 kg/cm2 +30 % Kantenpressung

4. Energien: (utilities)

		bar Überdruck sind.	normal	max.	°C Temperatur sind.	normal	max.
4.1.	Dampf (steam) 2 bar Netz	2,2	2,5	2,8	130	145	260
b)	7 bar Netz	6,0	6,8	9,0	170	190	208
	20 bar Netz	16,0	17,0	19,5	215	240	300
	25 bar Netz	20,6	21,5	22,5	260	270	280
4.2.	Druckluft:	3,0	3,5	4,5	Temperatur °C: -20	+20	+ 40
b)					Feuchtigkeit: bis 100 %		
b)	Verunreinigungen: Spuren von: Öl, Wasser						

/3

Auslegungsdaten (Proj. Nr. 1499/APA)

		bar Überdruck min.	normal	max.	min norm max
b) 4.3.	Instrumenten-luft: (Instrument air)	3,5	7,5	8,0	Temperatur °C: + 20 + 20 + 40 Feuchtigkeit: trocken, Taupunkt -22° C bei 7 bar Verunreinigungen: keine
b) 4.4.	ND-Stickstoff: (Decke) (Nitrogen)	3,5	7,5	9,0	Temperatur °C: -20 + 20 + 40 Feuchtigkeit: 30 g/Nm3 Verunreinigungen: Öl, Wasser O2 < 2 %

4.5. Elektrische Energie (electrical energie)

Grundlage für die Errichtung der elektrischen Anlagen bilden die ÖVE-Vorschriften in der jeweils gültigen Fassung.

	Spannung	Phasenzahl	Frequenz	Bemerk
Motore > 160 kw	6 kv	3	50 Hz	Einzelfälle je nach Gegebenheit
Motore ≤ 160 kW	380 V Δ	3	50 Hz	
Beleuchtungs-installation (light)	380/220 V	3/Np	50 Hz	
Steuerspannung	220 V	2	50 Hz	
Stromversorgung für Meß- und Regelgeräte (el. energie for instruments)	24 V	2	50 Hz	
Signal- und Melde-einrichtungen	24 V	2	GS	Über Batterie mit Ladeeinrichtung
Magnetventile	24 V	2	GS	
Handwerkzeuge und Handleuchten	42 V	3 bzw. 2	50 Hz	

Elektrische Schutzmaßnahmen: (el. standards)

a) 6 kV-Netz: Schutzerdung nach ÖVE-EN1/1975

500 V-Netz: Schutzleitungssystem

a) 380/220 V-Netz: Fullung } nach ÖVE-EN1/1975

42 V-Netz: Kleinspannung

220V-Steuerspannung: Schutzleitungssystem

Auslegungsdaten (Proj. Nr. 1499/APA)

Blitzschutz: Errichtung und Überprüfung von Blitzschutzanlagen

a) nach ÖVE-E49/1976

4.5.1. Notstromversorgung:
Erforderliche Leistung ist angegeben

4.5.2. Elektroinstallationen in Boden, unter Flur oder auf Rohrbrücken werden den örtlichen Verhältnissen angepaßt.

4.6. Abwässer:

4.6.1. Abwasser, (Regen, Kühl-, Fabrikwasser und (waste water)
Fäkalien) werden abgeleitet:
Ausführung Beton, nicht säurefest, Kanalsohle 248,40.

4.6.2. Verunreinigungen:
Behördenvorschreibung beachten.

4.7. Wasser:
Flußwasser (Kühlwasser) (cooling water)

4.7.1. Physik. Daten:

b) Netzdruck: normal 2,9 bar
b) max. 3,2 bar } bezogen auf NN (±0,0 m)
min. 1,6 bar

Temperatur: max. 21° C
min. 1° C

Wasseraustrittstemperatur aus Wärmetauscher:
max. 40° C

Zulässige Kühlwassererwärmung: $\Delta t > 15^\circ$ C (in besonderen Fällen nach Absprache).

Fouling-Faktor: Für Wandtemperatur $< 50^\circ$ C: 2×10^{-4} $\frac{m^2\ h^\circ C}{kcal}$
wasserseitig:

$> 50^\circ$ C: 4×10^{-4} $\frac{m2\ h^\circ C}{kcal}$

4.7.2. Kühlwasserleitungen werden innerhalb der Anlage oberirdisch oder unterirdisch je nach Zweckmäßigkeit verlegt.

4.7.3. Wasseranalyse:
Tabelle siehe nächste Seite

An der Anlagengrenze steht gereinigtes kiesfiltriertes Donauwasser mit folgender Beschaffenheit zur Verfügung: - Industrial water (Danube)

	Durchschnittswerte.	Grenzwerte.	
pH	8,0		
Leitfähigkeit (conductivity)	263.10-6		S/cm
free CO_2	2,0		mg/l
O_2	6,7		mg/l
M-Wert	2,55		mval/l
Gesamthärte (hardness)	8,5°		dH
Karbonathärte	7,1°		dH
bleibende Härte	1,5°		dH
Mg	19,4		mg/l
Ca	58,8		mg/l
Abdampfrückstand bei 105°C	214		mg/l
Glührückstand bei 650°C	122		mg/l
$KMnO_4$ - Zehl	19	30	mg/l
Fe	0,31		mg/l
SiO_2	3,9		mg/l
HCO_3	156		mg/l
NO_2	0,08		mg/l
NO_3	14		mg/l
Chlorid als CL	9		mg/l
Sulfat als SO_4	29		mg/l
P_2O_5	0,19		mg/l
NH_4	0,12		mg/l
Na	6,6		mg/l
K	4,0		mg/l
P-Wert			mval/l
Schwebestoffe (suspended matter)	3-4	12 kurzfristig max. 200	mg/l

1) Fouling Faktor bei Rohrwandtemperaturen auf der Kühlwasserseite von

Wasserseitig $\leq 50°C : 2 \cdot 10^{-4} \frac{m^2\,h\,°C}{Kcal}$

$> 50°C : 4 \cdot 10^{-4} \frac{m^2\,h\,°C}{Kcal}$

E: Bemerkungen

./5

neu geschr.

77 02 16 MIN.
29 03 21 Jr.

VBLATT C1

CHEMIE LINZ AG

19	IND 1	IND 2	IND 3
Dat			
Gez			

Kühlwasser-Analyse Werk-Linz I

Proj. Nr.

Auslegungsdaten (proj. Nr. 1499/APA)

3. **Roh- und Betriebsstoffe:** (raw materials)

3.1. Kohlensäure gasförmig: (CO_2)

3.1.1. Druck aus der Single-Train-Anlage: (pressure)

b) min 1,2 normal 1,28 bar abs. (PFAH/406) max. 1,32

3.1.2. Temperatur: 85° C (später nach Verwirklichung der 2 bar-Dampferzeugung Druckvergasung ca. 60° C)

3.1.3. Analyse bezogen auf trockenes Gas:

CO2	99,2	bis	99,5 Vol %
H_2	0,4	bis	0,7 Vol %
N_2	0,050	bis	0,2 Vol %
O_2	0,0	bis	0,015 Vol %
Ar	0,005	bis	0,01 Vol %
CH_4	0,001	bis	0,01 Vol %
CO	0,001	bis	0,005 Vol %

Das Gas ist bei 1,2 (1,28) bar abs. und 85° C wasserdampfgesättigt.

NOx. 0

3.2. Ammoniak flüssig (NH_3) liquid

3.2.1.

bar Überdruck			°C Temperatur		
min.	normal	max.	min.	normal	max.
8	19	22	-30	+5	+30

3.2.2. Analyse:

NH_3	99,8	bis	99,9 Gew. %
H_2O	0,08	bis	0,10 Gew. %

S max. 1 ppm

Öl und Fette: geringste Spuren

Restgase: < 200 bis 400 Nml/100 g NH_3 fl.

Zusammensetzung der Restgase:

CO_2	1 bis	2	Vol %
H_2	20 bis	30	Vol %
CH_4	35 bis	55	Vol %
N_2+Ar	25 bis	30	Vol %

3.3. Ammoniak gasförmig (NH_3 - gas)

3.3.1.

bar Überdruck			°C Temperatur		
min.	normal	max.	min.	normal	max.
0,35	0,45	0,75	+2	+10	+15

./.

Anlegungsdaten (Proj. Nr. 1499/AIA)

5.3.1. Analyse wie NH_3 flüssig (Pkt. 5.2.2.)

6. Schallschutz: (*noise*)

6.1. Geräusche dürfen folgende Werte nicht überschreiten:
Im Maschinenhaus max. 85 dB "A" in einer Entfernung von 1 m rund um den Schallerzeuger.
Im Freien max. 85 dB "A", sonst wie vor.
Behördenvorschreibungen beachten!

14.1.80

Technischer Text zur Anfrage 62545/9354/SZ

Eine Ammoniakverdichteranlage bestehend aus:

A) 1 Kompl. NH3-Verdichter *mit vorgeschaltetem Abscheider*
für die Fördermengen max, a) 44 000 Nm3/h
b) 22 000 Nm3/h

B) 1 NH3-Vorwärmer

C) 1 NH3-Nachkühler samt Kondensatabscheider mit automatischer Entleerung

D) Ersatzteile

./2

DATENBLATT zu ANFRAGE [illegible]

VERWENDUNGSZWECK: Ammoniakanlage - Verdichter

BEZEICHNET ALS: 7 340 AUF ZNR: STÜCKZ: 1 GEW. LIEFERZ: 12 Mo

ZULASSIGKEIT [illegible]

[illegible]		[illegible] DER MASCHINE:
[illegible]		[illegible] DER MASCHINE:
[illegible]		[illegible] DER MASCHINE:
[illegible]		[illegible] DES MOTORS: nach Möglichkeit 3000
RELATIVE FEUCHTE [illegible]	70	LEISTUNG DES MOTORS:
GASZUSAMMENSETZUNG:	96 % NH_3, 4 % H_2O	SPERR- UND SPÜLMEDIUM: N_2 - Gas
[illegible]		[illegible] DRUCK: bis 6
DRUCK AM SAUGSTUTZEN:	1,0 ata	KÜHLMEDIUM: Flußwasser; HEIZMEDIUM: Dampf
DRUCK AM DRUCKSTUTZEN:	[illegible] ata	[illegible]; HEIZGAS
TEMP. AM SAUGSTUTZEN:	16 °C	[illegible]; BETRIEBSDRUCK: [illegible]
TEMP. AM DRUCKSTUTZEN:	°C	EINTRITTSTEMP.: 20 ÷ 21 °C; EINTRITTSTEMP.: max 240 °C
[illegible]	0,9 kg/m³	AUSTRITTSTEMP.: max 40 °C; AUSTRITTSTEMP.: °C

TECHNISCHE BESCHREIBUNG

I) AUSFÜHRUNG	X) Fördermenge: Einsatz
BAUART: Schraubenverdichter	Variante I: 46000 ÷ 10 % Nm³/h
LAGE DER WELLE: horizontal	Variante II: 21000 ÷ 6000
LAGE SAUGSTUTZEN (VOM ANTRIEB AUS):	
LAGE DRUCKSTUTZEN (VOM ANTRIEB AUS):	
DREHSINN (VOM ANTRIEB AUS):	XX) Verschmutzungsfaktor: 2·10⁻⁴ m² h °C/kcal
NW SAUGSTUTZEN / DRUCKSTUTZEN:	
FLANSCHAUSFÜHRUNG: ND [illegible] 2632 ETW 10	Schmierung:
[illegible]:	Öldruck
[illegible]:	Öltemperatur:
[illegible]:	vor Kühler / nach Kühler
WELLENABDICHTUNG:	Viskosität: °E bei 50 °C
ART DER LAGERUNG:	Ölbedarf:
ART DER SCHMIERUNG:	Füllmenge:
ART DER REGELUNG: Bypass	Hauptölpumpe: direkt angetrieben
ART DES ANTRIEBES: E-Motor	Hilfsölpumpe: mit E-Motor (Notbetrieb)
AUFSTELLUNGSORT: im Bau - Temp. min + 10 °C	Notölversorgung: falls erforderlich
HEIZUNG ERFORDERLICH FÜR: Siehe Schema Bl.	
Ölbehälterheizung falls erforderlich	Instrumentierung: bauseits
KÜHLUNG ERFORDERLICH FÜR:	Betrieb von getrennter Meßwarte
Kühlwasserbedarf	Meßstand am Ort
	Instrumentenspezifikation v. Anbieter
II) WERKSTOFFE	III) EINZUHALT. NORMEN U. VORSCHRIFTEN
PRODUKTBERÜHRTE TEILE GEHÄUSE: St.	PRÜFDRUCK FÜR GEHÄUSE: 1,5 x max. Enddruck
PRODUKTBERÜHRTE TEILE LÄUFER: St.	jedoch min. 2,2 ata
WELLENSCHUTZHÜLSE: St.	
[illegible]: St.	
[illegible]: St.	
DICHTUNGEN: Klingerit	ZULÄSSIGER LÄRMPEGEL: 85 dB (A)
KORROSIONSSCHUTZÜBERZUG:	IV) ABNAHMEVORSCHRIFTEN
	Werksabnahmezeugnis DIN 50049 - [illegible]
	alle druckführenden Teile
ANSTRICHAUSFÜHRUNG: [illegible]; FARBE: grau	

ANGEBOTSUMFANG | TECHNISCHE UNTERLAGEN

[illegible] | X GESAMTZEICHNUNG; X [illegible] TEIL

X Aufstellungsskizze mit Hauptabmessungen

ZUBEHÖR:

ERSATZ- UND RESERVETEILE: NACH EMPFEHLUNG DES ANBIETERS

BEMERKUNGEN | BEILAGEN

FORMBLATT [illegible] ANLAUFKURVE

FORMBLATT [illegible] KENNLINIE

BLATT 6

KREISELVERDICHTER

NH_3-Verdichter 7340

FORMBLATT 1 ZU ANFRAGE

A VERWENDUNGSZWECK Abscheider

Zur Abscheidung des NH_3-Wassers vor dem Verdichter

BEZEICHNET ALS: B 340 AUF ZNR: STÜCKZ: 1 GEW. LIEFERZ: 2

B AUSLEGUNGS- UND BETRIEBSDATEN (NACH DIN 28083)

IM BEHÄLTER		IM DOPPELMANTEL	
BETRIEBSDRUCK:	8,6 atü	BETRIEBSDRUCK:	atü
PRÜFDRUCK:	11 atü	PRÜFDRUCK:	atü
BETRIEBSTEMP:	60 °C	BETRIEBSTEMP:	°C
INHALT:	LTR	INHALT:	LTR
MEDIUM:	NH_3-Gas	MEDIUM:	

Durchflußmenge: Fördermenge,

Abzuscheidende Menge:

Variante I: } Spuren

I - - - II: }

Abscheidegrad:

Druckverlust: 100 mm WS

C TECHNISCHE BESCHREIBUNG

I) AUSFÜHRUNG

EINBAULAGE: senkrechte

DURCHMESSER:	mm	LÄNGE:	mm
ZYLINDR. LÄNGE:	mm	BREITE:	mm
FORM BODEN I:		HÖHE:	mm
FORM BODEN II:			
FORM BODEN III:			
WANDSTÄRKEN			
ZYL. MANTEL:	mm		
BODEN I:	mm		
BODEN II:	mm		
BODEN III:	mm		
FLANSCHAUSFÜHRUNG:	N DIN 2633	F NO 10	
	N DIN	F NO	

mit automatischer Entleerung

WÄRMEBEHANDLUNG: nach Bedarf

OBERFLÄCHENBEHANDLUNG INNEN:

OBERFLÄCHENBEHANDLUNG AUSSEN:

ISOLATION:

II) WERKSTOFFE

ALLE PRODUKTBERÜHRTEN TEILE: 4571

FLANSCHE: St | BUNDE: 4571

FLANSCHE:

SCHRAUBEN: 4.6

DICHTUNGEN: Klingerit

KORR. SCHUTZÜBERZUG: nur für Stahlteile

AUSSENANSTRICH: 19 | FARBE: grau

III) EINZUHALT. NORMEN U. VORSCHRIFTEN:

Österr. Werkstoff- u. Bauvorschriften

IV) ABNAHMEVORSCHRIFTEN

DICHTHEITSPROBE:

SCHWEISSNAHTPRÜFUNG:

WERKSTOFFATTESTE:

ISOLATIONSPRÜFUNG

X ANGEBOTSUMFANG

ZUBEHÖR:

ERSATZ- UND RESERVETEILE: NACH EMPFEHLUNG DES ANBIETERS

TECHNISCHE UNTERLAGEN

X GESAMTGEWICHT X GRÖSSTER DM:

X Maßblatt

E BEMERKUNGEN

F BEILAGEN

FORMBLATT M1 MASSKIZZE

FORMBLATT M1 BESTELLHINWEIS

BLATT 2

	IND 1	IND 2	IND 3
DAT	11.04.		
BEZ	Schaffer		
DEP	[illegible]		

NICHT TÜV-PFLICHTIGE BEHÄLTER

Abscheider B 340

PROJ. NR.: 9554/82

BLATT 2 VON 4 BL.

DATENBLATT zu ANFRAGE 92/6264/3334/3 ANGABE: ANBIETER

A VERWENDUNGSZWECK NH_3 - Verdampfer
Verdampfen von NH_3-Gas mit NH_3-Gas
BEZEICHNET ALS W344 AUF ZNR STÜCKZ 1 GEW LIEFERZ 12 Kg

B AUSLEGUNGS-UND BETRIEBSDATEN (NACH DIN 24021)

IN DEN ROHREN			UM DIE ROHRE		
BETRIEBSDRUCK	9,1 ATÜ	MEDIUM NH_3 mit H_2O gesättigt	BETRIEBSDRUCK	12 ATÜ	MEDIUM NH_3
PRÜFDRUCK	11 ATÜ	SPEZ GEW 0,721	PRÜFDRUCK	12 ATÜ	SPEZ GEW 0,721
BETRIEBSTEMP	60 °C	SPEZ WÄRME 0,51	BETRIEBSTEMP	°C	SPEZ WÄRME 0,51
INHALT	LTR	ZÄHIGKEIT BEI °C	INHALT	LTR	ZÄHIGKEIT BEI °C
EINTRITTSDRUCK	ATÜ	VERDAMPFUNGSWÄRME kcal/kg	EINTRITTSDRUCK	12 ATÜ	VERDAMPFUNGSWÄRME kcal/kg
AUSTRITTSDRUCK	9,04 ATÜ	DURCHFLUSSMENGE Fördermenge	AUSTRITTSDRUCK	ATÜ	DURCHFLUSSMENGE 802 kg/h Förder-menge
EINTRITTSTEMP	35 °C	DRUCKVERLUST	EINTRITTSTEMP	°C	DRUCKVERLUST
AUSTRITTSTEMP	60 °C	STRÖM GESCHW	AUSTRITTSTEMP	°C	STRÖM GESCHW
WÄRMEÜBERGZAHL		AGGR ZUSTEINTR gasf.	WÄRMEÜBERGZAHL		AGGR ZUSTEINTR gasf.
VERSCHM FAKTOR		AGGR ZUST AUSTR gasf.	VERSCHM FAKTOR		AGGR ZUST AUSTR gasf.

C TECHNISCHE BESCHREIBUNG

1) AUSFÜHRUNG

BAUART Rohrbündel
EINBAULAGE horizontal
MITTLERE AUSTAUSCHFLÄCHE m²
ROHRLÄNGE mm — ROHRDURCHMESSER 25 mm
ROHRZAHL — ROHRWANDSTÄRKE 2 mm
TEILUNG mm
MANTELSTÄRKEN — MANTEL mm
ROHRBODEN I mm — ROHRBODEN II mm
DECKEL I mm — DECKEL II mm

FLANSCHAUSFÜHRUNG N DIN 2653 F NO 10
N DIN F NO

ANZAHL DER UMLENKUNGEN IN DEN ROHREN keine

ANZAHL DER UMLENKBLECHE UM DIE ROHRE

WÄRMEBEHANDLUNG nach Bedarf

ISOLATION bauseits

Wärmemenge:
Variante I: 560000 Kcal/h
— " — II: 280000 — " —

2) WERKSTOFFE

ROHRE:	4571	MANTEL	St
ROHRBÖDEN:	4571	DECKEL	4571
RAUM IN DEN ROHREN		RAUM UM DIE ROHRE	
-FLANSCHE	St	-FLANSCHE	St
-BUNDE	4571	-BUNDE	
EINBAUTEN		UMLENKBLECHE	St
KORR SCHUTZ		KORR SCHUTZ	
OBERFLÄCHE		OBERFLÄCHE	
DICHTUNGEN	Klingerit	DICHTUNGEN	Klingerit

nur für Stahlteile
AUSSENANSTRICH ja FARBE grau

3) EINZUHALT NORMEN U VORSCHRIFTEN:
Österr. Werkstoff- u. Bauvorschriften

4) ABNAHMEVORSCHRIFTEN
BAUPRÜFUNG, DRUCKPROBE UND WERKSTOFFATTESTE NACH DEN ÖSTERREICHISCHEN VORSCHRIFTEN DURCH DEN FÜR DEN BESTELLER ZUSTÄNDIGEN TÜV

ISOLATIONSPRÜFUNG

D ANGEBOTSUMFANG

TECHNISCHE UNTERLAGEN
X GESAMTGEWICHT X ANSICHTEN
X Kabblatt

X ZUBEHÖR
X ERSATZ- UND RESERVETEILE: NACH EMPFEHLUNG DES ANBIETERS

E BEMERKUNGEN

F BEILAGEN
FORMBLATT NR MASSSKIZZE
FORMBLATT NR OD. NR BESTELLNUMMER

BLATT 5

[redacted] CHEMIE LINZ AG

NO | IND 1 | IND 2 | IND 3
DAT 13.11.92
BEZ Wagner
GEP

TÜV-PFLICHTIGE
WÄRMETAUSCHER
NH₃-Verdampfer W344

PROJ NR 9364/92
BLATT 6 VON 6

9.11.92

A VERWENDUNGSZWECK Nachkühler

Kühlung des NH_3-Gases nach dem Verdichter

BEZEICHNET ALS W345 AUF ZNR. STÜCKZ 1 GEW LIEFERZ 12 Mo

B AUSLEGUNGS- UND BETRIEBSDATEN (NACH DIN 28082)

AUSZUTAUSCHENDE WÄRMEMENGE: -

IN DEN ROHREN			UM DIE ROHRE		
BETRIEBSDRUCK	13 ATÜ	MEDIUM Flußwasser	BETRIEBSDRUCK	1,2 ATÜ	MEDIUM $NH_3 + H_2O$
PRÜFDRUCK	5 ATÜ	SPEZ. GEW 1	PRÜFDRUCK	2,2 ATÜ	SPEZ GEW ~0,77
BETRIEBSTEMP	40 °C	SPEZ WÄRME 1	BETRIEBSTEMP	°C	SPEZ WÄRME ~0,51
INHALT	L/R	ZÄHIGKEIT BEI °C	INHALT	L/R	ZÄHIGKEIT ÖD
EINTRITTSDRUCK	13 ATÜ	VERDAMPFUNGSWÄRME kcal/kg	EINTRITTSDRUCK	1,2 ATÜ	VERDAMPFUNGSWÄRME Ausgang
AUSTRITTSDRUCK	drucklos ATÜ	DURCHFLUSSMENGE	AUSTRITTSDRUCK	ATÜ	DURCHFLUSSMENGE Förderung
EINTRITTSTEMP	18-21 °C	DRUCKVERLUST	EINTRITTSTEMP	°C	DRUCKVERLUST 400 mm WS
AUSTRITTSTEMP	40 °C	STRÖM GESCHW	AUSTRITTSTEMP	25 °C	STRÖM GESCHW
WÄRMEÜBERG ZAHL		AGGR ZUST EINTR flüssig	WÄRMEÜBERG ZAHL		AGGR ZUST EINTR gasf.
VERSCHM FAKTOR 2.10⁻⁴ m²K/kcal		AGGR ZUST AUSTR flüssig	VERSCHM FAKTOR		AGGR ZUST AUSTR gasf. + fl.

C TECHNISCHE BESCHREIBUNG

1) AUSFÜHRUNG

BAUART Rohrbündel

EINBAULAGE senkrecht stehend

MITTLERE AUSTAUSCHFLÄCHE m²

ROHRLAYOUT mm		ROHRDURCHMESSER 25 mm	
ROHRZAHL		ROHRWANDSTÄRKE 2 mm	
TEILUNG mm			
WANDSTÄRKEN		MANTEL mm	
ROHRBODEN I mm		ROHRBODEN II mm	
DECKEL I mm		DECKEL II mm	

FLANSCHAUSFÜHRUNG N DIN 2653 F NO 10

N DIN F NO

ANZAHL DER UMLENKUNGEN IN DEN ROHREN keine

oben mit offener Wasserkammer

ANZAHL DER UMLENKBLECHE UM DIE ROHRE

WÄRMEBEHANDLUNG nach Bedarf

ISOLATION bauseits

2) WERKSTOFFE

RAUM IN DEN ROHREN		RÄUM UM DIE ROHRE	
ROHRE	4571	MANTEL	4571
ROHRBÖDEN	4571	DECKEL	St
-FLANSCHE	St	-FLANSCHE	St
-BUNDE	4571	-BUNDE	4571
EINBAUTEIL		UMLENKBLECHE	4571
KORR SCHUTZ		KORR SCHUTZ	
OBERFLÄCHE		OBERFLÄCHE	
DICHTUNGEN	Klingerit	DICHTUNGEN	Klingerit

nur für Stahlteile

ANSZENANSTRICH 1g FARBE grau

3) Wärmemenge:

Variante I: 3 000 000 kcal/h

- " - II: 1 500 000 - " -

3) EINZUHALT NORMEN U VORSCHRIFTEN:

österr. Werkstoff- u. Bauvorschriften

4) ABNAHMEVORSCHRIFTEN

BAUPRÜFUNG, DRUCKPROBE UND WERKSTOFFATTESTE NACH DEN ÖSTERREICHISCHEN VORSCHRIFTEN DURCH DEN FÜR DEN HERSTELLER ZUSTÄNDIGEN TÜV

ISOLATIONSPRÜFUNG.

D ANGEBOTSUMFANG

X ZUBEHÖR

X ERSATZ- UND RESERVETEILE NACH EMPFEHLUNG DES ANBIETERS

TECHNISCHE UNTERLAGEN

X GESAMTGEWICHT X GRÖSSTER BOL

X Maßblatt

E BEMERKUNGEN

F BEILAGEN

FORMBLATT M1 : MASSSKIZZE

FORMBLATT M2 OD. M3 BESTELL-ZEICHNUNG

BLATT					
5	[redacted] CHEMIE LINZ AG		IND 1	IND 2	IND 3
		DAT	13.11.90		
		GEZ	Mathes		
		GEP			

TÜV-PFLICHTIGE WÄRMETAUSCHER

Nachkühler W345

PROJEKT 8364/90

BLATT 1 VON 3 Bl.

DATENBLATT zu ANFRAGE 0Z/62599/8359/SA ANGABE: ANBIETER ANGABE: ÖSW

A VERWENDUNGSZWECK Abscheider

Zur Abscheidung des NH_3-Wassers nach dem Nachkühler

BEZEICHNET ALS B 341 AUF ZNR STUCKZ 1 GEW. LIEFERZ 12 Mo

B AUSLEGUNGS- UND BETRIEBSDATEN (NACH DIN 28082)

IM BEHÄLTER			IM DOPPELMANTEL		
BETRIEBSDRUCK:	4,2	atü	BETRIEBSDRUCK:		atü
PRÜFDRUCK:	4,2	atü	PRÜFDRUCK:		atü
BETRIEBSTEMP.:	50	°C	BETRIEBSTEMP.:		°C
INHALT:		LTR	INHALT:		LTR
MEDIUM:	NH_3-Gas + H_2O		MEDIUM:		

Durchflußmenge: Fördermenge

abzuscheidende Menge: NH_3-Wasser

Variante I: 2600 kg/h

-"- II: 1200 -"-

Abscheidegrad:

Druckverlust 450 mm WS

C TECHNISCHE BESCHREIBUNG

1) AUSFÜHRUNG

EINBAULAGE: senkrecht

DURCHMESSER: — mm

RUHENDE LÄNGE: — mm

FORM BODEN I:

FORM BODEN II:

FORM MANTEL:

ANSCHLÜSSE:

STK. MANTEL: mm

DURCHM.: mm

BODEN I: mm

BODEN II: mm

ROHRSCHWEISSFÜHRUNG: NENN. 2650 mm FNO 10

NENN. ENO

mit automatischer Entleerung

WÄRMEBEHANDLUNG: nach Bedarf

OBERFLÄCHENBEHANDLUNG INNEN

OBERFLÄCHENBEHANDLUNG AUSSEN

ISOLATION:

D WERKSTOFFE

HEINZUHALT. NORMEN U. VORSCHRIFTEN:

ALLE PRODUKTBERÜHRTEN TEILE: 4571 Österr. Werkstoff- u. Bauvorschriften:

MANTEL: — BODEN: 4571

FLANSCHE:

SCHRAUBEN: A6

DICHTUNGEN: Klingerit

4) ABNAHMEVORSCHRIFTEN

BAUPRÜFUNG, PROBEPROBE UND WERKSTOFFPRÜFUNG NACH DEN ÖSTERREICHISCHEN VORSCHRIFTEN DURCH DEN FÜR DEN HERSTELLER ZUSTÄNDIGEN TÜV.

SCHWEISSNAHTPRÜFUNG: 5 % für Behälter

RÖNTGENPRÜFUNG: ja PRÜFDR.: atm

ISOLATIONSPRÜFUNG:

ANGEBOTSUMFANG

ZUBEHÖR

ERSATZ- UND RESERVETEILE: NACH EMPFEHLUNG DES ANBIETERS

BEMERKUNGEN

TECHNISCHE UNTERLAGEN

GESAMTGEWICHT: Konstruktion TÜV

Maßblatt:

E BEILAGEN

FORMBLATT M1 Werkstoffe

FORMBLATT ZU CO, NC, ÖSTERR. UMFANG

BLATT		ENG SIND ZU NO 2		TÜV-PFLICHTIGE BEHÄLTER	PROJ. NR. 9956/3
3	[redacted] CHEMIE LINZ AG	DAT			BLATT 3 VON 9 Bl.
		GEZ		Abscheider B 341	

1325 WEKA/Wac/Ob 1973 11 2

Technischer Text zur Anfrage 62545/9354/SZ

Elektrische Energie:

Für Antriebsmotore > 132 kW:	6000 V, 50 Hz
Für Motore < 132 kW :	500 V, 50 Hz
Steuerspannung:	220 V
Ex-Schutz am Aufstellungsort:	Exe 1 G1
Kompressorregelung:	bei konstanter Verdichterdrehzahl mittels Bypaß
Betriebsweise:	24stündiger Dauerbetrieb
Aufstellungsort:	in einem allseits geschlossenen Kompressorenhaus.

Lärmpegel: Der zulässige Lärmpegel in einem Meter Abstand von d. Maschine darf 85 d B (A) nicht überschreiten.
Sollten zur Erreichung dieses Lärmpegels Schaltschutzmaßnahmen (Schallschutzhaube, Schalldämpfer etc.) erforderlich sein, bitten wir Sie diese mitanzubieten.

Angebotsumfang beim Verdichter:

a) 1 kompl. Verdichter für 44000 Nm3/h bzw. 22000 Nm3/h
b) ev. nötiges Getriebe

c) Kompl. Druckölschmierung mit Haupt- u. Hilfsölpumpe, Ölkühler, Ölfilter, Rohrleitungen und Armaturen.
d) Kompl. Fundamentrahmen mit Ankerschrauben
e) Kompl. Regeleinrichtung
f) Alle für den Betrieb und die Überwachung nötigen Meß- und Steuergeräte.

D) **Ersatzteile:**

1 Satz Drehkolben mit Wellen

./8

Techniscner Text zur Anfrage 62545/9354/SZ

1 Satz Steuerzahnräder mit Nabe
1 Satz Läuferlager
1 Satz Wellenabdichtung
1 Ölpumpe
1 Rohrbündel für Ölkühler
1 Ölfiltereinsatz
und zusätzlich Ihres Erachtens nach noch erforderliche Reserveteile.
Die Preise bitten wir positionsweise getrennt anzubieten.

Angebotslegung bis : 1973 12 07

Nicht zu Ihrer Lieferung gehören:
Sämtliche Bauarbeiten, Fundamente, Antriebsmotore mit Schalt- und Schutzgeräten, Kupplungen, Isolation, Ölfüllung, Montage

Dem Angebot sind beizulegen (3fach):
Maßblätter d. Verdichters und aller Apparate
Skizze des Fundamentes
Gewichte des Verdichters u. d. Apparate
Schema d. Wellenabdichtung mittels Sperrgas
Anlaufmomentenkurve
Liste der Meß- und Regelgeräte

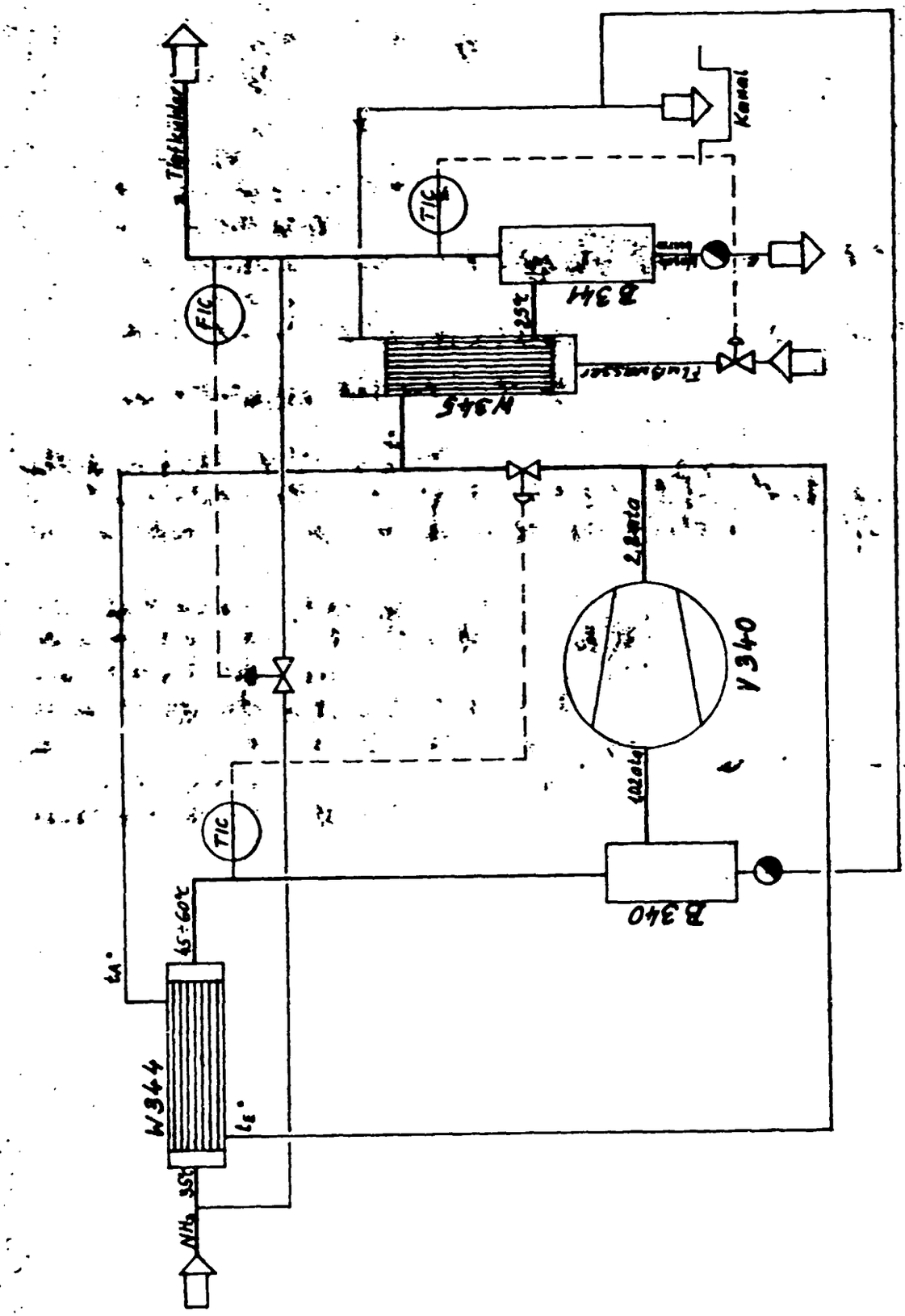
/9

BEILAGE zu ANFRAGE OZ/[illegible]/9354/SZ ANGABE: ANBIETER ANGABE: USW.

A: VERWENDUNGSZWECK für dichter schema

B: BEZEICHNET ALS AUF ZNR.

C: MASZSKIZZE



INBLATT 149	CHEMIE LINZ AG	1973	IND 1	IND 2	IND 3	Schema 731105	PROJ NR 9354/SZ
		DAT	11 05				BLATT 3 VON 9 BL
		GEZ	[illegible]				
		GEP	A[illegible]				

13x

Terminplan (Kurzfassung)
Stand vom: 1980 11 26

Titel: CO_2 - Verflüssigungsanlage
Proj. Nr.: 1499/KWL Bau Nr.: 219

Blatt 1
(1 Blätter

Lieferzeit
Bauarbeiten
Montage

verbindliche Absprache am:
Verteiler: KWL, THW, TEL, TBW, TME, AT, APA, MTE, T, TKB

	1981												1982											
	2	3	4	5	6	7	8	9	10	11	12		14	15	16	17	18	19	20	21	22	23	24	
Vertragsabschluß	→																							
Neuplanung und Infrastrukturprogramm																								
Angebotseinholung																								
Technische Klärungen																								
Bestellungen TKB für Apparate und Maschinen																								
Maschinen u. Apparate mit langer Lieferzeit																								
Maschinen u. Apparate mit kürzerer Lieferzeit																								
Isolierung Apparate																								
Verbindliche technische Unterlagen von Fremdfirmen																								
Bautechnische Ausschreibung																								
Pfählung																								
Bauarbeiten																								
Modell																								
Isometrien																								
Rohrleitungen																								
Isolierung Rohrleitungen																								
Meß- und Regeltechnik																								
Elektrotechnik																								
Stahlbau, Vorfertigung und Montage																								
Probeläufe																								
Inbetriebnahme																								

Änderungsschluß

Graz, 1980 11 26

CHEMIE LINZ MELAMINE PROCESS

1. Process Description

Melamine, a raw material for the plastic industry, has been so far produced from calcium cyanamide via dicyandiamide, but is now mainly produced from urea.

The CHEMIE LINZ AG succeeded in developing a continuous process at atmospheric pressure for the production of melamine from urea, thus achieving a technical progress solving all problems satisfactory.

The CHEMIE LINZ - melamine process operates at atmospheric pressure. The formation of melamine proceeds - in the same way as in case of all other processes starting from urea - according to the overall equation:

$$6\ CO(NH_2)_2 \longrightarrow C_3N_3(NH_2)_3 + 6\ NH_3 + 3\ CO_2$$

The reaction is endothermic.

The melamine is produced in two steps. First, urea is thermally decomposed into an equimolar mixture of isocyanic acid and ammonia:

$$CO(NH_2)_2 \longrightarrow HNCO + NH_3$$

H = + 780 kcal/kg urea (solid), endothermic reaction.

This gas mixture is diluted with additional ammonia, and led to a catalytic reaction. During this second step the isocyanic acid is converted into melamine and carbon dioxide.

$$6\ HNCO \longrightarrow C_3N_3(NH_2)_3 + 3\ CO_2$$

H = - 714 kcal/kg melamine, exothermic reaction.

These separate process steps permit carrying out each reaction within the optimum temperature range. Consequently the formation of unwanted by-products is reduced to a minimum; and a recrystallization is not necessary.

The first reaction takes place in a heated fluidized sand bed. These is practically no abrasion and therefore the reation gases need not to be filtered. The second reaction is effected in a fixed catalyst bed. There is no contamination of the product gases due to catalyst dust. Such contamination would necessiate filtration and crystallization. The reaction heat of the second reaction is controlled by cooling devices. The reaction heat is used for preheating ammonia. The melamine formed in the catalyst bed is gaseous at reaction temperature. It is condensed in a subsequent cooler, where melamine crystals are formed in a aqueous suspension. The remaining components of the reaction gas mixture can thus be separated from the suspension very easily.

The melamine can be easily separated from the mother liquor by a centrifuge or a filter. Due to this wet separation as well as the subsequent drying melamine with high bulk density is obtained. High bulk density is an advantage for storage, transport and further processing.

According to the overall equation, 2,86 tons of urea are theoretically needed for the production of 1 ton of melamine with 0,81 tons of ammonia and 1,05 tons of carbon dioxide as by-product.

As the formation of melamine from isocyanic acid has a yield of 91 - 95 % in practice 3,1 tons of urea are required to produce 1 ton of melamine.

The unreacted isocyanic acid is hydrolized into ammonia and carbon dioxide or rebuilt to urea.

2. Process Description of a Melamine Plant

If the urea to be treated is available in solid form this is first melted with steam (1,2). If urea is available in liquid form the melting is of course waived. The melt is delivered to the decomposer (3) by pumps. The heat required for decomposition of the urea is obtained from a circulation salt bath which is maintained at the right temperature. The reaction takes place in a sand bed reactor, fluidized with hot ammonia. In the decomposer (3) a gas mixture consisting of isocyanic acid and ammonia is formed. This is delivered to the catalyst reactor (5), where the isocyanic acid is converted to gaseous melamine, and carbon dioxide is set free. The reaction heat is used to preheat ammonia.

The mixture of gaseous melamine, ammonia and carbon dioxide goes to the separator (6), where fine-crystalline melamine, suspended water is obtained by direct cooling.

Due to extraction of heat by water evaporation the separation gases entrain water vaporous. A great part of this water vapour is condensed in the following off-gas-cooler (7) and returns to the separator (6). The off-gas is sent to the off-gas treatment unit.

The suspension from the separator (6) is pumped into a collecting tank (8) and cooled via cooler (9), whereby part of the dissolved melamine will crystallize.

The suspension is pumped to the centrifuge or filter (10) where melamine crystals and liquid are separated. The mother liquor is recirculated to the melamine separator where it served as a cooling agent.

To obtain the desired moisture in the final product, the melamine from the centrifuge of filter is dried in drier (11). The cooling zone in the drier cools the melamine so as to be suitable for storage.

Subsequent sieve (12) and mill (13) enable removal of agglomerats formed in the drier.

The product from the drier is ready for sale. It is weighed (14), bagged and stored.

3. Off-Gas Uitilization

The off-gas consists of carbon dioxide, water vapour, inert gases and a lot of ammonia. The major part of this ammonia was fed to the catalytic reactor in the synthesis for the fluidization. The minor part was set free during reaction.

There are different alternatives available for utilizing the off-gas and mother liquor economically.

The following possibilities may be mentioned:

a) Separation and return of the ammonia from the synthesis and absorption of the residual off-gas to produce an ammonium carbonate solution.

This carbonate solution can be delivered to fertilizer plants for conversion into ammonium nitrate, ammonium sulphate or ammonium phosphate.

When passing this ammonium carbonate solution to an urea plant, consideration should be paid to the fact that the high percentage of water reduces the efficiency of conversion into urea.

An improvement is obtained through conversion of the ammonium carbonate into an ammonium carbamate solution, thus reducing the water rate.

A better alternative would be, however, according to a process, developed by Chemie Linz and used in several plants.

b) Obtain an ammonium carbonate solution as in a) above and separate this into ammonia, carbon dioxide and water which only marginal increase in investment and utility requirements.

Thus the melamine plant is independent from any other plant, because the pure ammonia can be exported in liquid form or used anywhere.

4. Process Description of an Off-Gas Treatment Unit

The off-gas goes to the ammonium carbonate column (= NH_3-separation, 21) where CO_2 is washed out forming an ammonium carbonate liquor supersaturated with ammonia. The surplus of ammonia is cooled and dried with liquor ammonia on the top of the column. Bulk of this ammonia is compressed (16), preheated (4) and returned directly to the melamine plant for re-use. A small part of this ammonia stream is further compressed (17), liquified (18), separated from residual inert gases and fed to the top of the ammonium carbonate column (21).

The balance of the ammonia gas obtained at the top of the column (21) leaves the plant and is available for further use in other units. This quantity corresponds to the ammonia produced during the melamine synthesis.

The ammonium carbonate solution is stripped off from the free ammonia in the NH_3-stripper (15) and delivered to the lower stage of the CO_2-stripper (19), which operates under elevated pressure. In the lower steam heated stage, the ammonium carbonate solution is decomposed. In the upper stage the NH_3 is scrubbed with water and the pure CO_2 leaves the plant for further use. The ammonia water, obtained in the sump, which still contains slight amounts of carbon dioxide, transfers its heat in the NH_3-CO_2-stripper (20). A main part goes to the ammonium carbonate column (21). The remainder is decomposed in the NH_3-CO_2-stripper (20). Gases expelled in this column are recycled to the ammonium carbonate column (21). The separated water can be used as washing water or purged.

Consumption Figures per Ton (Metric) of Melamine

Consumption		Expected
Urea (100 %)		3,10 t
NH_3 liquid		0,3 t
Process water (condensate)		1,2 t
Catalyst (2 years life-time)		2,50 kg
Electric power	6 kV	500 kWh
	500 V	280 kWh
Fuel		14,4 GJ
Steam	15 bar	3,0 t
	6 bar	4,0 t
Cooling water	15°C	800 m^3
Nitorgen	5 bar	40 Nm^3
Instrument air		40 Nm^3
Compressed air		400 Nm^3

Credit

NH_3 gas	1 bar	1,2 t
CO_2 gas	20 bar	1,10 t
Condensate		5,00 t

Effluent

Mother liquor from recrystall. with 1 kg melamie	0,03 m^3
20 g NaOH	
90 g Na-ammelide	
Cooling water	800 m^3

CHEMIE LINZ-MELAMINE PROCESS

1. Melt vessel
2. Circ. heater
3. Decomposer
4. NH_3-preheater
5. Contact furnace
6. Separator
7. Recooler
8. Collecting vessel
9. Circ. cooler
10. Centrifuge
11. Drier
12. Sieve
13. Mill
14. Scales
15. NH_3-Stripper
16. NH_3-compressor
17. NH_3-compressor
18. Condenser
19. CO_2-separation
20. H_2O-separation
21. NH_3-separation

SD·75·3111