ภาคผนวก

ภาคผนวก ก

ตาราง ก.1 ตารางการเลือกวัสดุของปั๊ม

A —designates an all bronze pump
B —designates a bronze fitted pump
C —designates an all iron pump

Summary of Material Selections and ASTM* Standards Designations

Material Selection	Corresponding National Society Standards Designation: ASTM*	Remarks
1	A48, Classes 20, 25, 30, 35, 40 & 50	Gray iron—Six Grades
1(a)	A536 & A395	Ductile Cast iron—Six Grades
2	B584	Tin Bronze & Leaded Tin Bronze—seven alloys
3	A216-WCB	Carbon Steel
4	A217-C5	5% Chromium Steel
5	A743-CA15	12% Chromium Steel
6	A743-CB30	20% Chromium Steel
7	A743-CC50	28% Chromium Steel
8	A743-CF-8	19-9 Austenitic Steel
9	A743-CF-8M	19-10 Molybdenum Austenitic Steel
10	A743-CN-7M	20-29 Chromium Nickel Austenitic Steel with Copper & Molybdenum
11		A series of nickel-base alloys
12	A518	Corrosion Resistant High-silicon cast iron
13	A436	Austenitic cast iron—2 types
13(a)	A439	Ductile Austenitic Cast iron
14		Nickel-Copper alloy
15		Nickel
16		Duplex stainless steel—typically 25% chromium, 5% nickel, 3% molybdenum + nitrogen

*ASTM—denotes American Society for Testing Materials.

(ที่มา หนังสือ CAMERON HYDRAULIC DATA)

ตาราง ก.2 วัสดุปั๊ม

Pump Materials

*Materials of Construction For Pumping Various Liquids

Column 1	Column 2	Column 3	Column 4	Column 5
Liquid	Condition of liquid	Chemical symbol	Specific gravity	Material selection
Acetaldehyde		C_2H_4O	0.78	C
Acetate Solvents				A,B,C,8,9,10,11,16
Acetone		C_3H_6O	0.79	B,C
Acetic Anhydride		$C_4H_6O_3$	1.08	8,9,10,11,12,16
Acid, Acetic	Conc, Cold	$C_2H_4O_2$	1.05	8,9,10,11,12,16
Acid, Acetic	Dil Cold			8,9,10,11,12,16
Acid, Acetic	Conc Boiling			9,10,11,12,16
Acid, Acetic	Dil Boiling			9,10,11,12,16
Acid, Arsenic, Ortho-		$H_3AsO_4 \cdot \frac{1}{2}H_2O$	2.0-2.5	8,9,10,11,12
Acid, Benzoic		$C_7H_6O_2$	1.27	8,9,10,11,16
Acid, Boric	Aqueous Sol	H_3BO_3		A,8,9,10,11,12,16
Acid, Butyric	Conc	$C_4H_8O_2$	0.96	8,9,10,11,16
Acid, Carbolic	Conc (M P 106 F)	C_6H_6O	1.07	C,8,9,10,11,16
Acid, Carbolic	(See Phenol)			B,8,9,10,11,16
Acid, Carbonic	Aqueous Sol	$CO_2 \cdot H_2O$		4,8,16
Acid, Chromic	Aqueous Sol	$CrO_3 \cdot H_2O$		8,9,10,11,12,16
Acid, Citric	Aqueous Sol	$C_6H_8O_7 \cdot H_2O$		8,9,10,11,12,16
Acids, Fatty (Oleic, Palmitic, Stearic, etc.)				8,9,10,11,16
Acid, Formic		CH_2O_2	1.22	9,10,11,16
Acid, Fruit				A,8,9,10,11,14,16
Acid, Hydrochloric	Comi Conc	HCl	1.19 (38%)	11
Acid, Hydrochloric	Dil Cold			11
Acid, Hydrochloric	Dil Hot			11
Acid, Hydrocyanic		HCN	0.70	C,8,9,10,11,16
Acid, Hydrofluoric	Anhydrous, with Hydro Carbon	$HF \cdot H_xC_x$		3,14
Acid, Hydrofluoric	Aqueous Sol	HF		14
Acid, Hydrofluosilicic		H_2SiF_6	1.30	14
Acid, Lactic		$C_3H_6O_3$	1.25	A,8,9,10,11,12,16
Acid, Mine Water				A,C,5,8,9,10,11,16
Acid, Mixed	Sulfuric—Nitric			8,9,10,11,12,16
Acid, Muriatic	(See Acid, Hydrochloric)			
Acid, Naphthenic				C,5,8,9,10,11,16
Acid, Nitric	Conc Boiling	HNO_3	1.50	11,16
Acid, Nitric	Dilute			8,9,10,11,12,16
Acid, Oxalic	Cold	$C_2H_2O_4 \cdot 2H_2O$	1.65	9,10,11,12,16
Acid, Oxalic	Hot	$C_2H_2O_4 \cdot 2H_2O$		10,11,12
Acid, Ortho-Phosphoric		H_3PO_4	1.87	9,10,11,16
Acid, Picric		$C_6H_3N_3O_7$	1.76	8,9,10,11,12,16
Acid, Pyrogallic		$C_6H_6O_3$	1.45	8,9,10,11,16
Acid, Pyroligneous				A,8,9,10,11,16
Acid, Sulfuric	77% Cold	H_2SO_4	1.69-1.84	C,10,11,12
Acid, Sulfuric	65/93% > 175F			11,12
Acid, Sulfuric	65/93% < 175F			10,11,12
Acid, Sulfuric	10-65%			10,11,12
Acid, Sulfuric	10%			10,11,12,14
Acid, Sulfuric (Oleum)	Fuming	$H_2SO_4 + SO_3$	1.92-1.94	3,10,11
Acid, Sulfurous		H_2SO_3		8,9,10,11,16
Acid, Tannic		$C_{76}H_{52}O_{46}$		A,3,8,9,10,11,14,16
Acid, Tartaric	Aqueous Sol	$C_4H_6O_6 \cdot H_2O$		A,8,9,10,11,14,16
Alcohols				A,B,C,3
Alum	See Aluminum Sulphate and Potash Alum)			
Aluminum Sulphate	Aqueous Sol. (up to 200°F)	$Al_2(SO_4)_3$		10,11,12,14
Ammonium, Aqua		NH_4OH		C,8,9,16

*Materials of Construction For Pumping Various Liquids (cont.)

Column 1 Liquid	Column 2 Condition of liquid	Column 3 Chemical symbol	Column 4 Specific gravity	Column 5 Material selection
Ammonium Bicarbonate	Aqueous Sol	NH_4HCO_3		C, 3, 5
Ammonium Chloride	Aqueous Sol	NH_4Cl		9, 10, 11, 12, 14, 16
Ammonium Nitrate	Aqueous Sol	NH_4NO_3		C, 8, 9, 10, 11, 14, 16
Ammonium Phosphate Dibasic	Aqueous Sol	$(NH_4)_2HPO_4$		C, 8, 9, 10, 11, 14, 16
Ammonium Sulfate	Aqueous Sol	$(NH_4)_2SO_4$		8, 9, 10, 11, 16
Ammonium Sulfate	With sulfuric acid			9, 10, 11, 12, 16
Aniline		$C_6H_5NH_2$	1 02	B, C
Aniline Hydrochloride	Aqueous Sol	$C_6H_5NH_2HCl$		11, 12
Asphalt	Hot		0 98 - 1 4	C, 5
Barium Chloride	Aqueous Sol	$BaCl_2$		C, 8, 9, 10, 11, 16
Barium Nitrate	Aqueous Sol	$Ba(NO_3)_2$		C, 8, 9, 10, 11, 16
Beer				A, 8, 16
Beer Wort				A, 8, 16
Beet Juice				A, 8, 16
Beet Pulp				A, B, 8, 9, 10, 11, 16
Benzene		C_6H_6	0 88	
Benzine	(See Petroleum ether)			
Benzol	(See Benzene)			B, C
Bichloride of Mercury	(See Mercuric Chloride)			
Black Liquor	(See Liquor, Pulp Mill)			
Bleach Solutions	(See type)			
Blood				A, B
Boiled Feedwater	(See Water, Boiler Feed)			
Brine, Calcium Chloride	pH 8	$CaCl_2$		C, 11, 13, 14
Brine, Calcium Chloride	pH - 8			A, 10, 11, 13, 14
Brine, Calcium & Magnesium Chlorides	Aqueous Sol			A, 10, 11, 13, 14
Brine, Calcium & Sodium Chloride	Aqueous Sol			A, 10, 11, 13, 14
Brine, Sodium Chloride	Under 3% Salt, Cold	$NaCl$		A, 13
Brine, Sodium Chloride	Over 3% Salt, Cold		1 02 - 1 20	A, 8, 9, 10, 11, 13, 14, 16
Brine, Sodium Chloride	Over 3% Salt, Hot			9, 10, 11, 12, 14, 16
Brine, Sea Water			1 03	A, B
Butane		C_4H_{10}	0 60 @ 32F	B, C, 3
Calcium Bisulfite	Paper Mill	$Ca(HSO_3)_2$	1 06	9, 10, 11, 16
Calcium Chlorate	Aqueous Sol	$Ca(ClO_3)_2H_2O$		10, 11, 12
Calcium Hypochlorite		$Ca(OCl)_2$		10, 11, 12
Calcium Magnesium Chloride	(See Brines)			
Cane Juice				A, B, 8, 13, 16
Carbon Bisulfide		CS_2	1 26	C
Carbonate of Soda	(See Soda Ash)			
Carbon Tetrachloride	Anhydrous	CCl_4	1 50	B, C
Carbon Tetrachloride	Plus Water			A, 8, 16
Catsup				A, 8, 9, 10, 11, 16
Caustic Potash	(See Potassium Hydroxide)			
Caustic Soda	(See Sodium Hydroxide)			
Cellulose Acetate				9, 10, 11, 16
Chlorate of Lime	(See Calcium Chlorate)			

*Materials of Construction For Pumping Various Liquids (cont.)

Column 1	Column 2	Column 3	Column 4	Column 5
Liquid	Condition of liquid	Chemical symbol	Specific gravity	Material selection
Chloride of Lime	(See Calcium Hypochlorite)			
Chlorine Water	(Depending on conc.)			9, 10, 11, 12, 16
Chlorobenzene		C_6H_5Cl	1.1	A, B, 8, 16
Chloroform		$CHCl_3$	1.5	A, 8, 9, 10, 11, 14, 16
Chrome Alum	Aqueous Sol	$CrK(SO_4)_2 \cdot 12H_2O$		10, 11, 12
Condensate	(See Water Distilled)			
Copperas Green	(See Ferrous Sulfate)			
Copper Ammonium Acetate	Aqueous Sol			C, 8, 9, 10, 11, 16
Copper Chloride (Cupric)	Aqueous Sol	$CuCl_2$		11, 12
Copper Nitrate		$Cu(NO_3)_2$		8, 9, 10, 11, 16
Copper Sulfate, Blue Vitriol	Aqueous Sol	$CuSO_4$		8, 9, 10, 11, 12, 16
Creosote	(See Oil, Creosote)			
Cresol, Meta		C_7H_8O	1.03	C, 5, 9, 16
Cyanide	(See Sodium Cyanide and Potassium Cyanide)			
Cyanogen	In Water	$(CN)_2$ Gas		C
Diphenyl		$C_6H_5 \cdot C_6H_5$	99	C, 3
Enamel				C
Ethanol	(See Alcohols)			
Ethylene Chloride (di-chloride)	Cold	$C_2H_4Cl_2$	1.28	A, 8, 9, 10, 11, 14, 16
Ferric Chloride	Aqueous Sol	$FeCl_3$		11, 12
Ferric Sulphate	Aqueous Sol	$Fe_2(SO_4)_3$		8, 9, 10, 11, 12, 16
Ferrous Chloride	Cold Aqueous	$FeCl_2$		11, 12
Ferrous Sulphate (Green Copperas)	Aqueous Sol	$FeSO_4$		9, 10, 11, 12, 14, 16
Formaldehyde		CH_2O	1.08	A, 8, 9, 10, 11, 16
Fruit Juices				A, 8, 9, 10, 11, 14, 16
Furfural		$C_5H_4O_2$	1.16	A, C, 8, 9, 10, 11, 16
Gasoline			0.68–0.75	B, C
Glaubers Salt	(See Sodium Sulfate)			
Glucose				A, B
Glue	Hot			B, C
Glue Sizing				A
Glycerol (Glycerin)		$C_3H_8O_3$	1.26	A, B, C
Green Liquor	(See Liquor, Pulp Mill)			
Heptane		C_7H_{16}	0.69	B, C
Hydrogen Peroxide	Aqueous Sol	H_2O_2		8, 9, 10, 11, 16
Hydrogen Sulfide	Aqueous Sol	H_2S		8, 9, 10, 11, 16
Hydrosulfite of Soda	(See Sodium Hydrosulfite)			
Hyposulfite of Soda	(See Sodium Thiosulfate)			
Kaolin Slip	Suspension in Water			C, 3
Kaolin Slip	Suspension in Acid			9, 10, 11, 12, 16
Kerosene	(See Oil, Kerosene)			
Lard	Hot			B, C
Lead Acetate (Sugar of Lead)	Aqueous Sol	$Pb(C_2H_3O_2)_2 \cdot 3H_2O$		9, 10, 11, 14, 16
Lead	Molten			C, 3
Lime Water (Milk of Lime)		$Ca(OH)_2$		C
Liquor—Pulp Mill Black				C, 3, 9, 10, 11, 12, 14, 16

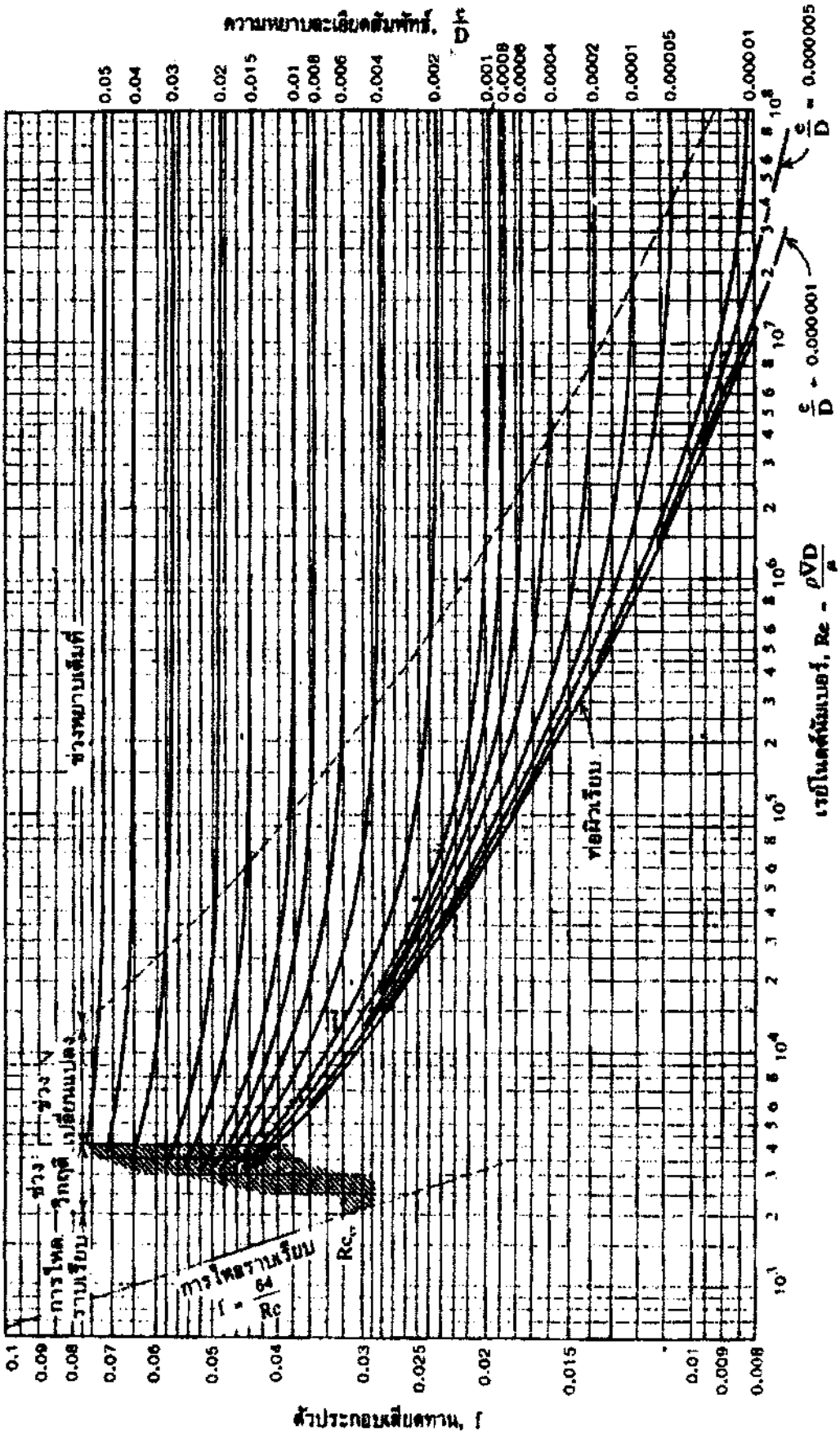
*Materials of Construction For Pumping Various Liquids (cont.)

Column 1	Column 2	Column 3	Column 4	Column 5
Liquid	Condition of liquid	Chemical symbol	Specific gravity	Material selection
Paraffin	Hot			B, C
Perhydrol	(See Hydrogen Peroxide)			
Peroxide of Hydrogen	(See Hydrogen Peroxide			
Petroleum Ether				B, C
Phenol		C_6H_6O	1.07	C, 8, 9, 10, 11, 16
Pink Liquor	(See Liquor, Pulp Mill)			
Photographic Developers				8, 9, 10, 11, 16
Plating Solutions	(Varied and complicated consult pump mfgrs.)			
Potash	Plant Liquor			A, 8, 9, 10, 11, 13, 14, 16
Potash Alum	Aqueous Sol	$Al_2(SO_4)_3K_2SO_4 \cdot 24H_2O$		A, 9, 10, 11, 12, 13, 14, 16
Potassium Bichromate	Aqueous Sol	$K_2Cr_2O_7$		C
Potassium Carbonate	Aqueous Sol	K_2CO_3		C
Potassium Chlorate	Aqueous Sol	$KClO_3$		8, 9, 10, 11, 12, 16
Potassium Chloride	Aqueous Sol	KCl		A, 8, 9, 10, 11, 14, 16
Potassium Cyanide	Aqueous Sol	KCN		C
Potassium Hydroxide	Aqueous Sol	KOH		C, 5, 8, 9, 10, 11, 13, 14, 15, 16
Potassium Nitrate	Aqueous Sol	KNO_3		C, 5, 8, 9, 10, 11, 16
Potassium Sulfate	Aqueous Sol	K_2SO_4		A, 8, 9, 10, 11, 16
Propane		C_3H_8	0.58 @ 48F	B, C, 3
Pyridine		C_5H_5N	0.98	C
Pyridine Sulphate				10, 12
Rhodolene				B, C
Rosin (Colophony)	Paper Mill			C
Sal Ammoniac	(See Ammonium Chloride)			
Salt Lake	Aqueous Sol	Na_2SO_4 — impurities		A, 8, 9, 10, 11, 12, 16
Salt Water	(See Brines)			
Sea Water	(See Brines)			
Sewage				A, B, C, 8, 16
Shellac				A
Silver Nitrate	Aqueous Sol	$AgNO_3$		8, 9, 10, 11, 12, 16
Slop, Brewery				A, 8, C
Slop, Distillers				A, 8, 9, 10, 11, 16
Soap Liquor				C, 8, 16
Soda Ash	Cold	Na_2CO_3		C, 8, 16
Soda Ash	Hot			8, 9, 10, 11, 13, 14, 16
Sodium Bicarbonate	Aqueous Sol	$NaHCO_3$		C, 8, 9, 10, 11, 13, 16
Sodium Bisulfate	Aqueous Sol	$NaHSO_4$		10, 11, 12
Sodium Carbonate	(See Soda Ash)			
Sodium Chlorate	Aqueous Sol	$NaClO_3$		8, 9, 10, 11, 12, 16
Sodium Chloride	(See Brines)			
Sodium Cyanide	Aqueous Sol	NaCN		C
Sodium Hydroxide	Aqueous Sol	NaOH		C, 5, 8, 9, 10, 11, 13, 14, 15, 16
Sodium Hydrosulfide	Aqueous Sol	$Na_2S_2O_4 \cdot 2H_2O$		8, 9, 10, 11, 16
Sodium Hypochlorite		NaOCl		11, 12
Sodium Hyposulfite	(See Sodium Thiosulfate)			
Sodium Meta Silicate				C
Sodium Nitrate	Aqueous Sol	$NaNO_3$		C, 5, 8, 9, 10, 11, 16
Sodium Phosphate Monobasic	Aqueous Sol	$NaH_2PO_4H_2O$		A, 8, 9, 10, 11, 16

*Materials of Construction For Pumping Various Liquids (cont.)

Column 1	Column 2	Column 3	Column 4	Column 5
Liquid	Condition of liquid	Chemical Symbol	Specific gravity	Material selection
Sodium Phosphate Dibasic	Aqueous Sol	$Na_2HPO_4 \cdot 7H_2O$		A, C, 8, 9, 10, 11, 16
Sodium Phosphate Tribasic	Aqueous Sol	$Na_3PO_4 \cdot 2H_2O$		C
Sodium Phosphate Meta	Aqueous Sol	$Na_4P_2O_7$		A, 8, 9, 10, 11, 16
Sodium Phosphate Hexameta	Aqueous Sol	$(NaPO_3)_6$		8, 9, 10, 11, 16
Sodium Plumbite	Aqueous Sol			C
Sodium Sulfate	Aqueous Sol	Na_2SO_4		A, 8, 9, 10, 11, 16
Sodium Sulfide	Aqueous Sol	Na_2S		C, 8, 9, 10, 11, 16
Sodium Sulfite	Aqueous Sol	Na_2SO_3		A, 8, 9, 10, 11, 16
Sodium Thiosulfate	Aqueous Sol	$Na_2S_2O_3 \cdot 5H_2O$		8, 9, 10, 11, 16
Stannic Chloride	Aqueous Sol	$SnCl_4$		11, 12
Stannous Chloride	Aqueous Sol	$SnCl_2$		11, 12
Starch		$(C_6H_{10}O_5)_n$		A, 8
Strontium Nitrate	Aqueous Sol	$Sr(NO_3)_2$		C, 8, 16
Sugar	Aqueous Sol			A, 8, 9, 10, 11, 13, 16
Sulfite Liquor	(See Liquor, Pulp Mill)			
Sulfur	In Water	S		A, C, 8, 9, 10, 11, 16
Sulfur	Molten	S		C
Sulfur Chloride	Cold	S_2Cl_2		C
Syrup	(See Sugar)			
Tallow	Hot		0.90	C
Tanning Liquors				A, 8, 9, 10, 11, 12, 14, 16
Tar	Hot			C, 3
Tar & Ammonia	In Water			C
Tetrachloride of Tin	(See Stannic Chloride)			
Tetraethyl Lead		$Pb(C_2H_5)_4$	1.66	B, C
Toluene (Toluol)		C_7H_8	0.87	B, C
Trichloroethylene		C_2HCl_3	1.47	A, B, C, 8, 16
Urine				A, 8, 9, 10, 11, 16
Varnish				A, B, C, 8, 14, 16
Vegetable Juices				A, 8, 9, 10, 11, 14, 16
Vinegar				A, 8, 9, 10, 11, 12, 16
Vitriol, Blue	(See Copper Sulfate)			
Vitriol, Green	(See Ferrous Sulfate)			
Vitriol, Oil of	(See Acid, Sulfuric)			
Vitriol, White	(See Zinc Sulfate)			
Water, Boiler Feed	Not evaporated pH 8.5		1.00	C, 5
High Makeup	pH 8.5			B, C, 5
Low Makeup	Evaporated, any pH		1.66	4, 5, 8, 14, 16
Water, Distilled	High Purity		0.87	A, 8, 16
Water, Distilled	Condensate			A, B, 5
Water, Fresh			1.00	B, C, 5
Water, Mine	(See Acid, Mine Water)			
Water, Salt & Sea	(See Brines)			
Whiskey				A, 8, 16
White Liquor	(See Liquor, Pulp Mill)			
White Water	Paper Mill			A, B, C
Wine				A, B, 16
Wood Pulp (Stock)				A, B, C
Wood Vinegar	(See Acid, Pyroligneous)			
Wort	(See Beer, Wort)			
Xylol (Xylene)		C_8H_{10}	0.87	B, C, 8, 9, 10, 11, 16
Yeast				A, B, 8, 16
Zinc Chloride	Aqueous Sol	$ZnCl_2$		9, 10, 11, 12, 16
Zinc Sulfate	Aqueous Sol	$ZnSO_4$		A, 9, 10, 11, 16

ภาคผนวก ข.



รูปที่ ข.1 แผนภาพโมดี้ (ที่มาหนังสือกลศาสตร์ของไหล ฉบับเสริมประสบการณ์)

Type of pipe (new, clean, condition)	Absolute roughness* ϵ (in feet)
Drawn tubing—glass, brass, plastic	0.000005
Commercial steel or wrought iron	0.00015
Cast iron—asphalt dipped	0.0004
Galvanized iron	0.0005
Cast iron—uncoated	0.00085
Wood stave	0.0006–0.0003
Concrete	0.001–0.01
Riveted steel	0.003–0.03

* Basis data from Hydraulic Institute Engineering Data Book.

รูปที่ ข.2 ตารางแสดงค่า Absolute roughness

(ที่มา หนังสือ CAMERON HYDRAULIC DATA)

ภาคผนวก ค.

ตาราง ค.1 ช่วงของความเร็วที่เหมาะสมของไอน้ำ

ภายใต้เงื่อนไขต่างๆ

Conditions	Velocities	
	m/s	ft/s
1. Exhaust Steam	20-30	70-100
2. Saturated Steam (up to 1 barg)	18-30	60-100
3. Saturated Steam (3 barg and above)	30-40	100-130
4. Superheated Steam	40-60	130-200

(ที่มา หนังสือ38 เรื่องน่ารู้ ระบบท่อ – ระบายอากาศ – ทำความร้อน)

ตาราง ค.2 ค่าคุณสมบัติต่างๆของไอน้ำ

ความดัน (psig)	อุณหภูมิ (°F)	ความร้อนสัมผัส (Btu/lb)	ความร้อนแฝง (Btu/lb)	ความร้อนรวม (Btu/lb)	ปริมาตรจำเพาะ (ft^3/lb)
0	212	180	971	1151	26.8
3	221	190	964	1154	22.5
9	237	206	954	1160	17.0
13	246	214	949	1163	15.1
17	253	222	943	1165	13.0
21	260	229	939	1168	11.7
25	267	236	935	1170	10.6
29	273	242	931	1172	9.7
33	278	247	927	1174	8.9
37	283	252	923	1175	8.25
41	288	257	920	1177	7.70
45	292	262	916	1178	7.21
49	297	266	913	1179	6.78
53	300	270	910	1181	6.40
60	308	278	905	1183	5.84
70	316	287	898	1185	6.19
80	324	295	892	1187	4.67
90	331	302	887	1189	4.24
100	338	309	882	1190	3.89
110	344	316	876	1192	3.58
120	350	322	872	1193	3.34
130	356	328	867	1195	3.12
140	361	333	862	1196	2.93
150	366	339	858	1197	2.76
160	371	344	854	1198	2.61

ตาราง ค.3 ขนาดของท่อไอน้ำ

ความดัน (psig)	ความเร็ว (ft/s)	ปริมาณการไหลของไอน้ำ (lb/hr)										
		1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"	6"
5	50	12	26	45	70	100	190	280	410	780	1250	1770
	80	19	45	75	115	170	300	490	710	1250	1800	2700
	120	29	60	110	175	245	460	700	1000	1800	2800	4000
10	50	15	35	55	88	130	240	365	580	950	1500	2200
	80	24	52	95	150	210	380	600	900	1500	2400	3300
	120	36	72	135	210	330	590	850	1250	2200	3400	4800
20	50	21	47	82	123	185	320	520	740	1340	1980	2900
	80	32	70	120	190	280	520	810	1100	1900	3100	4500
	120	50	105	190	300	440	840	1250	1720	3100	4850	6750
30	50	26	56	100	160	230	420	650	950	1660	2600	3650
	80	42	94	155	260	380	655	950	1460	2700	3900	5600
	120	62	130	240	370	570	990	1560	2100	3950	6100	8700
40	50	32	75	120	190	260	505	790	1100	1900	3100	4200
	80	51	110	195	300	445	840	1250	1800	3120	4900	6800
	120	75	160	290	480	660	1100	1900	2700	4700	7500	11000
60	50	43	95	160	260	360	650	1000	1470	2700	3900	5700
	80	65	140	250	400	600	1000	1650	2400	4400	6500	9400
	120	102	240	410	610	950	1680	2600	3600	6500	10300	14700
80	50	53	120	215	315	460	780	1300	1900	3200	5200	7000
	80	85	190	320	500	730	1300	2100	3000	5000	8400	12200
	120	130	280	500	750	1100	1900	3000	4200	7900	12000	17500
100	50	62	130	240	360	570	980	1560	2100	4000	6100	8800
	80	102	240	400	610	950	1660	2660	3700	6400	10200	14600
	120	150	350	600	900	1370	2400	3700	5000	9100	15000	21000
120	50	74	160	280	440	660	1100	1850	2800	4600	7000	10500
	80	120	270	450	710	1030	1800	2800	4150	7200	11600	16500
	120	175	400	680	1060	1520	2650	4300	6500	10700	17500	26000
150	50	90	208	340	550	820	1380	2230	3220	5500	8600	12900
	80	145	320	570	900	1250	2200	3400	4900	8500	14000	20000
	120	215	450	850	1280	1890	3400	5300	7500	13400	20600	30000
200	50	110	265	450	680	1020	1780	2800	4120	7100	11500	16300
	80	180	410	700	1100	1560	2910	4400	6600	11000	18000	26600
	120	250	600	1100	1630	2400	4350	6600	9400	16900	25900	37000

(ที่มา หนังสือ38 เรื่องน่ารู้ ระบบท่อ – ระบายอากาศ – ทำความร้อน)

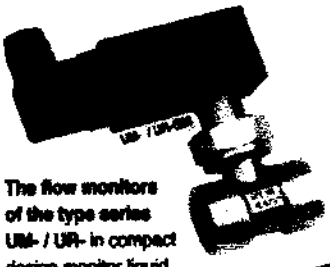
ภาคผนวก ง.

Flow Meters

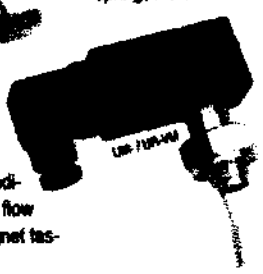
compomax | FLOW & LEVEL DIVISION

Flow monitor UM3K-/ UR3K- paddle

Flow



The flow monitors of the type series UM- / UR- in compact design monitor liquid media by means of a paddle. A spring supported stainless steel paddle is located in the flow chamber and moved by the incoming medium in the direction of flow. When a flow rate preset is approached, the magnet fastened to the paddle nears a magnet with opposite poles which is outside and linked to a reed or microswitch and thus generates a limit value, when the actual flow rate is above or below a nominal value preset. As the paddle is supported by a spring, the units can installed irrespective of the position. The units are supplied with internal thread on both sides (UM-GM) or socket connection piece (UM-VM) for direct installation into the pipe.

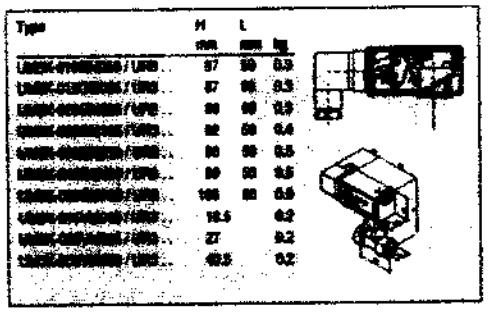


UM = microswitch
UR = readswitch

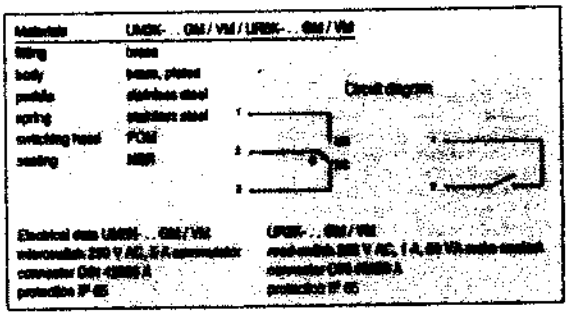
Characteristics / application

- installation independent of position
- hardly any pressure loss
- insensitive to pollution
- powerful microswitch used as commutator
- compact dimensions
- all functional parts made of stainless steel
- continuously adjustable limit

The units are used in industry and in initial configurations e.g. for cooling units, compressors.



Type	H mm	L mm	kg
UM3K-015GM65 / UR3..	87	65	0.3
UM3K-025GM65 / UR3..	87	65	0.3
UM3K-040GM80 / UR3..	89	80	0.5
UM3K-050GM80 / UR3..	89	80	0.5
UM3K-065GM80 / UR3..	89	80	0.5
UM3K-080GM80 / UR3..	89	80	0.5
UM3K-100GM80 / UR3..	105	80	0.5
UM3K-015VM / UR3..	16.5		0.2
UM3K-025VM / UR3..	27		0.2
UM3K-050VM / UR3..	49.5		0.2



Materials	UM3K-..GM / VM / UR3K-..GM / VM
fitting	brass
body	brass, plated
paddle	stainless steel
spring	stainless steel
switching head	POM
sealing	NBR

Circuit diagram

Electrical data UM3K-..GM / VM: microswitch 250 V AC, 5 A, commutator; connector DIN 43650 A; protection IP 65

UR3K-..GM / VM: reed switch 250 V AC, 1 A, 60 VA, make contact; connector DIN 43650 A; protection IP 65

	Internal thread			UM	UR		
	¼	UM3K-015GM65 / UR3..	25	110	5.5 – 5	5 – 6.5	16
	½	UM3K-015GM65 / UR3..	25	110	5 – 6.5	5 – 6.5	20
	¾	UM3K-025GM65 / UR3..	25	110	7 – 9.5	8 – 8.5	40
	1	UM3K-025GM65 / UR3..	25	110	13 – 16.5	12 – 16	60
	1¼	UM3K-040GM80 / UR3..	25	110	21 – 27	20 – 22	80
	1½	UM3K-040GM80 / UR3..	25	110	35 – 46	34 – 44	100
	2	UM3K-040GM80 / UR3..	25	110	60 – 76	54 – 69	150
	Ring ¾" / connection piece						
15	½	UM3K-015VM / UR3..	25	110	19 – 13	8.5 – 11	20
20			25	110	17.5 – 22	14 – 19	40
25	¾	UM3K-025VM / UR3..	25	110	19 – 22.5	16 – 20	60
32			25	110	44 – 55.5	39 – 52	100
40			25	110	56.5 – 72	49 – 64	150
50	1	UM3K-050VM / UR3..	25	110	75 – 90	58 – 84	200
65			25	110	151 – 186	127 – 163	400
80			25	110	228 – 280	189 – 248	600

930450	930420	with
930451	930421	valid
930452	930422	yellow dot
930453	930423	
930454	930424	
930456	930425	
930455	930426	
930457	930427	
930458	930428	
930459	930429	
930460	930430	
930462	930432	
930461	930431	
930462	930432	

P hysteresis: UM 15%, UR 10 % , tolerance ± 15 %

รูปที่ 3.1 Flow meter UM3K-/UR3K-paddle

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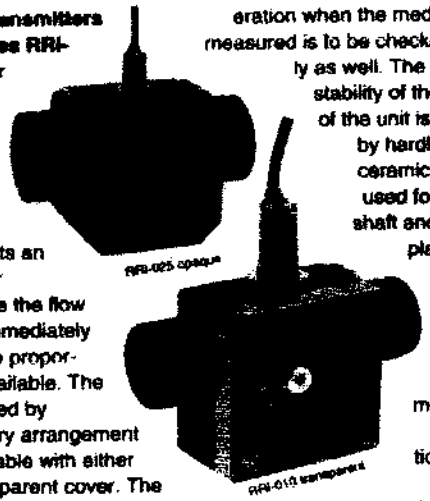
Flow rate transmitter RRI- rotor

Flow

The flow rate transmitters of the type series RRI- generate a linear and flow rate proportional frequency signal. A plastic rotor equipped with stainless steel caps selects an inductive sensor arranged outside the flow chamber and immediately making flow rate proportional pulses available. The units are mounted by adapters in rotary arrangement and made available with either opaque or transparent cover. The latter should be taken into consideration when the medium to be measured is to be checked visually as well. The long-term stability of the function of the unit is achieved by hardly wearing ceramic materials used for the rotor shaft and resisting plastic bearings. The adapters in rotary arrangement permit best positioning after the installation.

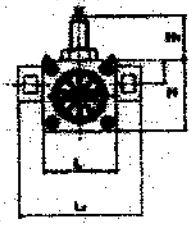


Characteristics / application:

- fully plastic design
- high pulse resolution
- good linearity
- installation independent of position
- wide measuring ranges
- usable up to 10 cSt
- no magnetic materials inside
- no straight inline required

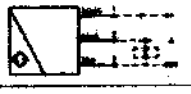
The units are exploited in plant construction and process technique, as monitors in metering operations, for continuous control of heating systems, for the monitoring of emulsions in machine tools, automatic welding machines etc.

Ø	Type	H	H1	L	L1	
		mm	mm	mm	mm	kg
¼	RRI-010GVP	60	16	60	85	0.2
1	RRI-025GVP	70	28	70	110	0.5



Electrical data		Materials	RRI- ..P
supply voltage	5 – 30 V DC	casing	PBM
residual ripple	± 10 %	cover	PBM / PC transp.
max. power consumption	10 mA	adapter	PVDF
max. output voltage	200 mA	rotor	PVDF
output	4 – 29 V square signal	caps	1.4310
output switch	PNP	shaft	ceramics
frequency	10 – 1000 Hz max.	bearings	lgilidur
protection	IP 67	o-ring	Viton
connection	cable 2 m		

Circuit diagram



Connection: internal thread

¼	RRI-010GVP020V10	16	60	0.1 – 1.5	10200	3	0.5	931500	931505
	RRI-010GVP040V10	16	60	0.2 – 10	3345	15	0.5	931501	931507
	RRI-010GVP070V10	16	60	0.4 – 12	1755	20	0.5	931502	931508
1	RRI-025GVP080V10	16	60	2 – 30	1218	40	0.5	931503	931509
	RRI-025GVP120V10	16	60	3 – 60	807	80	0.5	931504	931510
	RRI-025GVP160V10	16	60	4 – 100	252	120	0.5	931505	931511

accuracy ± 3 %; repetitive accuracy ± 1 %; max. viscosity 10 cSt
In case of higher viscosities alteration to measured data and tolerances.

รูปที่ 4.2 Flow Rate Transmitter RRI-Rotor

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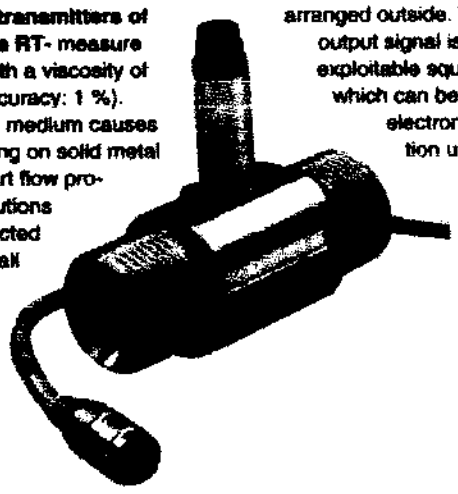
Flow rate transmitters RT- turbine

Flow

The flow rate transmitters of the type series RT- measure liquid media with a viscosity of up to 5 cSt (accuracy: 1 %). The flow of the medium causes turbine operating on solid metal bearings to start flow proportional revolutions which are detected by a biassed hall sensor



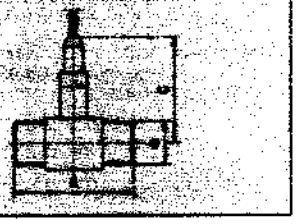
arranged outside. The linear output signal is a directly exploitable square signal which can be fed to the electronic evaluation unit without further amplification.

Characteristics / application:

- fully metallic design (stainless steel)
- no magnetic materials in the medium
- high preasure-duty capacity
- independent of position
- wide measuring ranges
- high accuracy

The units are used in the chemical industry and process technique, for dosing and mixing operations.

Q	Type	G	DN	H	
		mm	mm	mm	kg
¼ A	RT-015AK	G¼	15	71	0.3
½ A	RT-020AK	G½	20	74	0.4
1 A	RT-025AK	G1	25	76	1.2
1¼ A	RT-032AK	G1¼	32	84	1.5
2 A	RT-050AK	G2	50	84	3.0



Materials	RT- . . AK
body	1.4571
rotor	1.4401
bearings / shaft	hard metal -
sealings	Viton
Electrical data	
supply voltage	10 – 30 V DC ± 10 %
residual ripple	± 10 %
max. output current	100 mA
output	4 – 400 Hz square
output switch	PNP
protection	IP 68
connection electrical	connector + 2 m cable short circuit proof and with reverse battery protection
Connection mechanical	male thread

Circuit diagram

¼	RT-015AK001	250	125	0.11 – 1.1	full range	0.3	931700	see valid
½	RT-020AK002	250	125	0.22 – 2.2	+20 %	0.3	931701	
¾	RT-020AK004	250	125	0.4 – 4	accuracy	0.3	931702	
¾	RT-025AK006	250	125	0.6 – 6	± 1 % remaining value	0.3	931703	
1	RT-025AK010	250	125	1.0 – 10		0.3	931704	
1½	RT-040AK024	250	125	3.4 – 34		0.3	931705	
2	RT-050AK068	250	125	6.8 – 68		0.3	931706	

Installation instructions:
filtration: recommended 500 my
calming sector: recommended 16 x D inlet, 10 x D outlet
installation position: preferably horizontal, specify deviations
Viscosities exceeding 5 cSt will influence the measured data.

รูปที่ 4.3 Flow Rate Transmitter RT-Turbine

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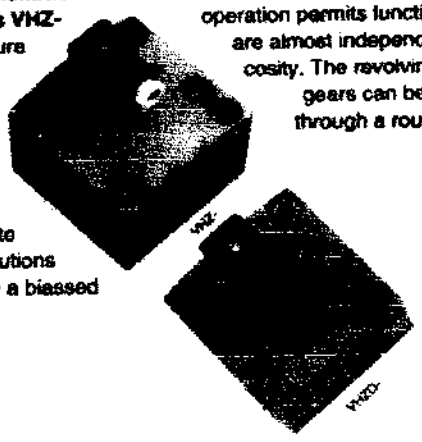
Flow rate transmitters VHZ- gear

Flow

The flow rate transmitters of the type series VHZ- are used to measure viscous liquids. The medium passes a defined inlet bore and causes a pair of gears to move with flow rate proportional revolutions being scanned by a biassed hall sensor. The purely volumetric operation permits functions which are almost independent of viscosity. The revolving function gears can be observed through a round inspection glass.

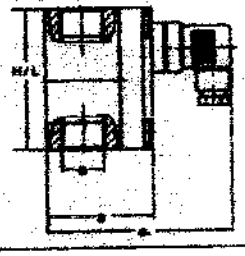


Characteristics / application:

- installation independent of position
- independent of viscosity due to volumetric function
- measuring range 1:100, from 0.1 l/min.
- good accuracy of ± 3 %
- no magnetic internal parts in the medium chamber

The units are applied in hydraulic systems and lubrication technique for the monitoring of oil circuits, e.g. in printing machines, tension jacks for tools, gear units, paper machines etc. The transmitters are also suitable for the measurement of other self-lubricating viscous liquids.

G.	Type	H mm	B mm	B1 mm	L mm	kg
%	VHZ-010GA/S6P	86	80	97	55	0.3
%	VHZ-[illegible]GA/S6P	90	66	115	90	0.6
%	VHZO-[illegible]GA/S6P	90	66	115	90	0.6

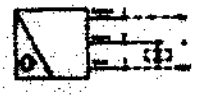


Materials	VHZ-...GA	VHZO-...GA
casing	aluminium, anodised	aluminium, anodised
cover	aluminium, anodised	aluminium, anodised
shaft	steel, 1.4462	steel, 1.4462
gears	steel, 1.4462	steel, 1.4462
bearings	igidur	igidur
sealings	Viton	Viton
inspection glass	—	glass

Electrical data	
supply voltage	10 – 30 V DC
max. output current	100 mA
output	4 – 400 Hz square
output switch	PNP
protection	IP 65
connection	connector DIN 43650-A short circuit proof and with reverse battery protection

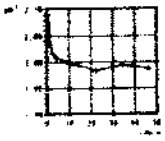
connection: internal thread

Circuit diagram



%	VHZ010GA/S6P	200	80	0.1 – 6	± 3 (20 mm²/s)		931800
%	VHZ050GA/S6P	200	80	0.5 – 50	± 3 (20 mm²/s)	1 – 20,000 not usable for water and solutions	931801
%	VHZO630GA/S6P incl. sight glass	168	80	0.5 – 50	± 3 (20 mm²/s)		931802

Installation:
Installation is effected torsion-free into the cleaned pipe.
Abrasive and foreign substances exceeding 100 micron have to be avoided.



รูปที่ 3.4 Flow Rate Transmitter VHZ-Gear

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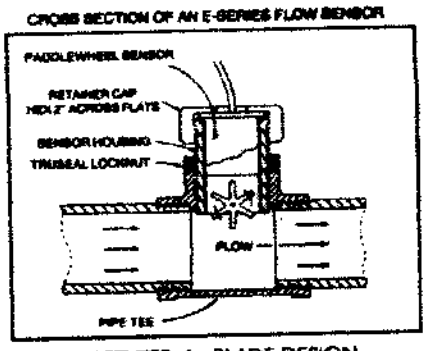
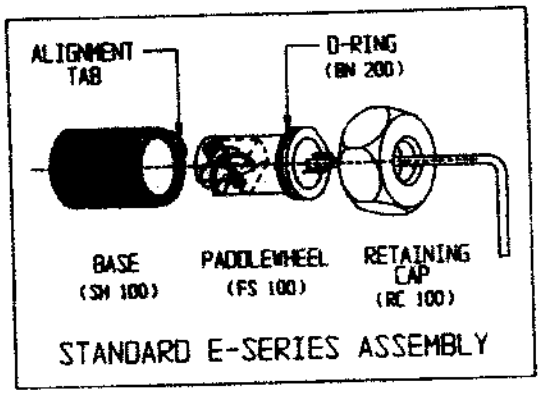
the PADDLEWHEELS

LIQUID FLOWMETERS

* Low Cost * 2 Yr Warranty * High Reliability
* High Sensitivity * Pipe Sizes From 1/2" - 72"
* Wide Range 0.6 - 25,000+ GPM
* Patented 6 Blade Non-Magnetic Design
* Available in DELRIN or KYNAR
* One Paddlewheel fits ALL SIZES
* Direct Logic Pulse Output
* Transmits up to 1000 feet without need for additional amplifiers.

CROSS SECTION OF AN E-SERIES FLOW SENSOR





PATENTED 6 - BLADE DESIGN

One major problem with most paddlewheel flow-sensors having magnets in the paddles is that metal particles tend to stick to the magnets. The collecting material then causes a change in the flow characteristics of the paddle. To eliminate this problem, Micro Contract Manufacturing Flowsensors use a special axle and dual magnet drum design. This takes the magnets out of the paddles. By using the dual magnetic drum design (rapidly changing polarity) this, along with the fluid velocity, causes the metallic particles to drop off into the flow and be swept away.

New Long Life Tungsten Bearing

Our Paddlewheels or now available with a Tungstun Carbide Bearing for longer life in harsh environments. Consult factory for details.

the Specifications

ELECTRICAL	
FLOW RANGE	1.5 TO 70 fps
FREQUENCY RANGE	2 TO 105 Hz
OUTPUT SIGNAL	Open Collector Pulse
OUTPUT CURRENT	50 ma.
VOLTAGE REQUIREMENT	4.5 TO 24VDC
LINEARITY	+/- 0.5% Of Rate
REPEATABILITY	+/- 0.5% Of Rate
PHYSICAL	
STANDARD CABLE LENGTH	10 feet
PRESSURE SURGE	1000PSI (see fittings)
PRESSURE MAX (sensor only)	600PSI (see fittings)
TEMPERATURE MAX (sensor only)	250°F
SOLIDS MAX	10%
VISCOSITY MAX SSU	2000
CENTISTOKES	440
WETTED MATERIALS	
BODY / PADDLE	Delrin or PVDF
AXEL	316 SST or Hastelloy C
O RING	Buna-N, Viton, EPDM
OPTIONAL BEARING	Tungstun Carbide

The Paddlewheel Flowsensor output can simultaneously drive any number of Micro Contract Manufacturing's indicators, signal conditioners or controllers. In addition it can also serve as a direct input to PLCs counters, and controllers supplied by other manufacturers.

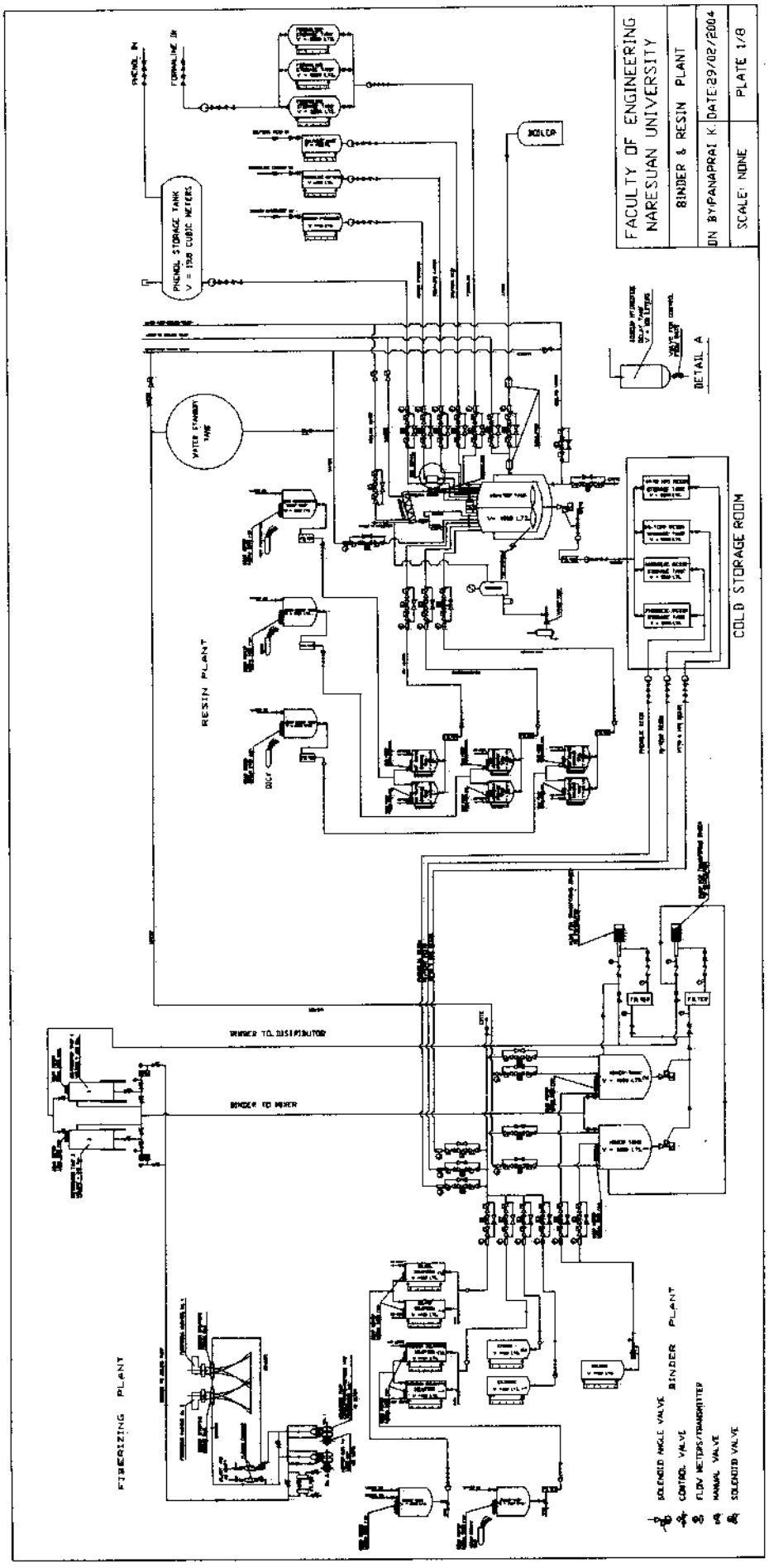
FLOW RANGE IN GPM per PIPE ID (GPM = Velocity(fps) x ID² x 2.45)

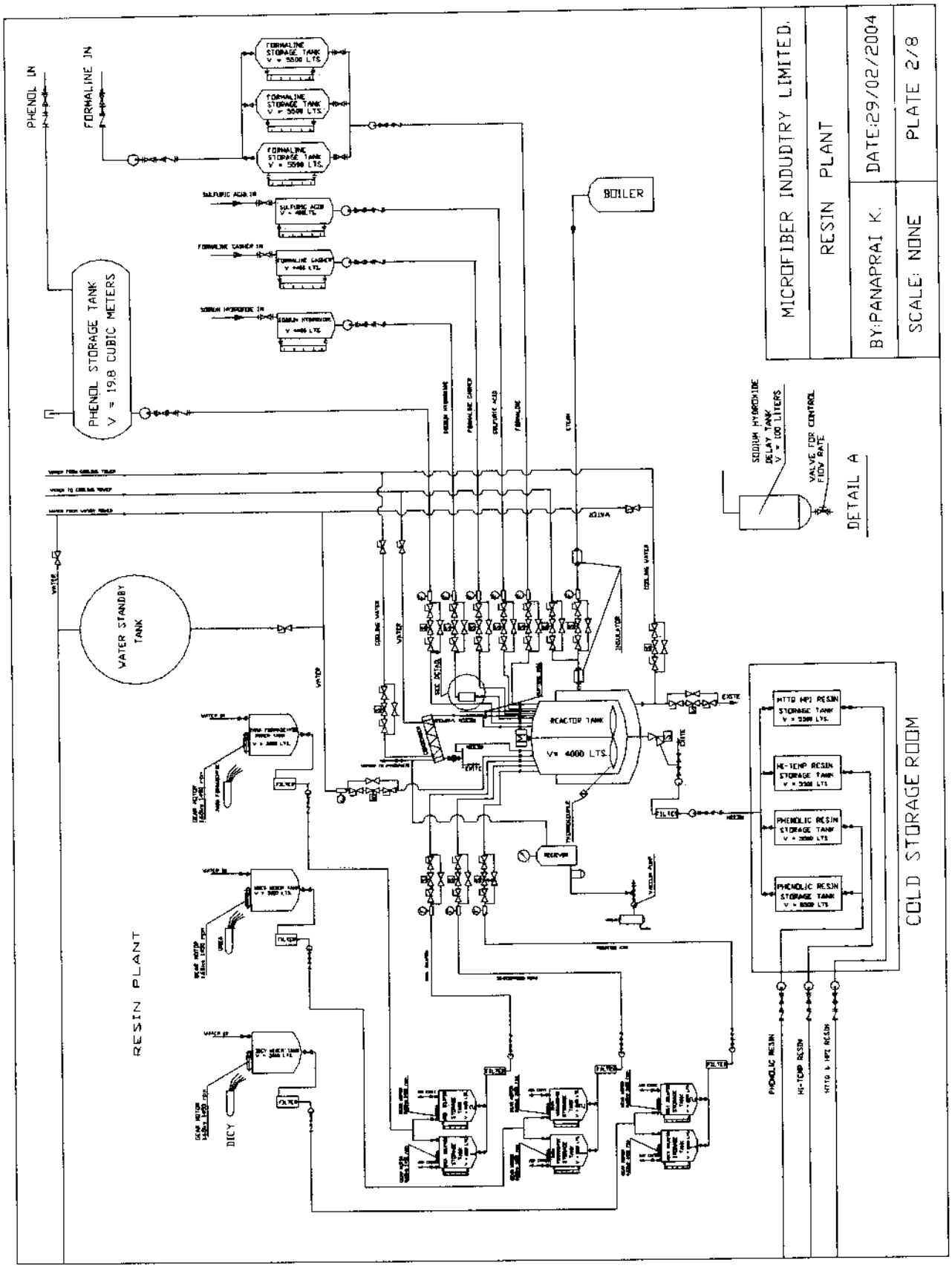
pipe size (inches)	(1.5 FtSec. Min Flow)	(70 FtSec. Max Flow)
Low Flow	0.60	27
3/4	2.07	96
1	3.67	171
1 1/4	5.74	268
1 1/2	8.26	386
2	14.70	686
2 1/2	22.96	1071
3	33.07	1543
4	58.80	2744
6	132.30	6174
8	235.20	10967
10	367.50	17150
12	529.20	24696
14	720.30	33614

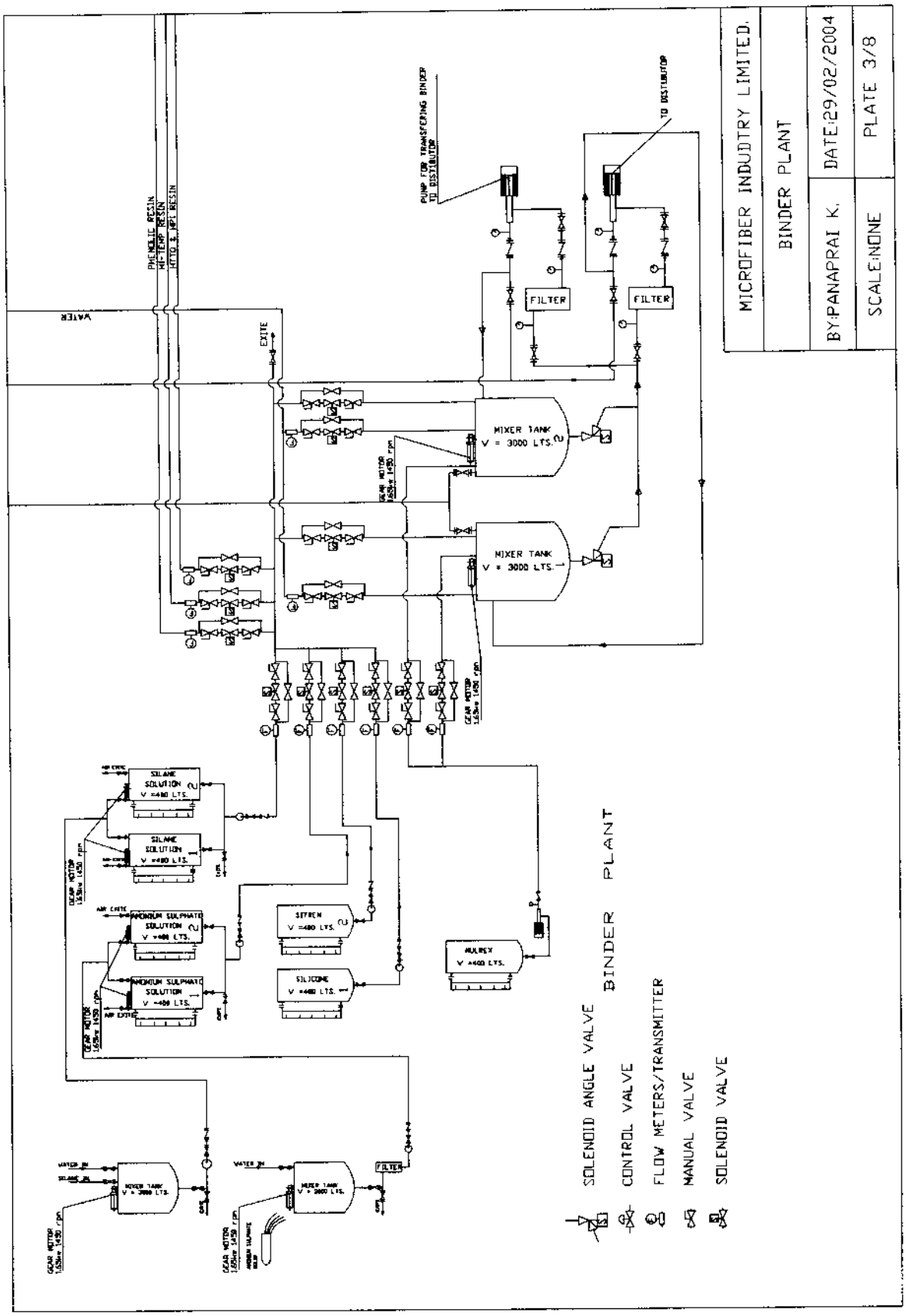
รูปที่ 4.5 Liquid Flow Meters

ภาคผนวก จ

แบบแปลนระบบท่อและระบบควบคุม


FACULTY OF ENGINEERING
NARESUAN UNIVERSITY
BINDER & RESIN PLANT
DN BY:PANAPRAI K. DATE:29/02/2004
SCALE: NONE
PLATE 1/8
PHENOL IN
FORMALINE IN
PHENOL STORAGE TANK
V = 1500 CUBIC METERS
BOILER
WATER STANDBY TANK
DETAIL A
RESIN PLANT
COLD STORAGE ROOM
WINNER TO DISTRIBUTOR
BINDER TO MIXER
FIBERIZING PLANT
BINDER PLANT
SOLENOID ANGLE VALVE
CONTROL VALVE
FLOW METERS/TRANSMITTER
MANUAL VALVE
SOLENOID VALVE


MICROFIBER INDUSTRY LIMITED.
RESIN PLANT
BY:PANAPRAI K.
DATE:29/02/2004
SCALE: NONE
PLATE 2/8
PHENOL IN
FORMALINE IN
PHENOL STORAGE TANK
V = 19.8 CUBIC METERS
FORMALINE STORAGE TANK
V = 5500 LTS.
BOILER
WATER STANDBY TANK
REACTOR TANK
V= 4000 LTS.
SODIUM HYDROXIDE DELAY TANK
V = 100 LITERS
VALVE FOR CONTROL FLOW RATE
DETAIL A
RESIN PLANT
COLD STORAGE ROOM
PHENOLIC RESIN STORAGE TANK
HI-TEMP RESIN STORAGE TANK
DICY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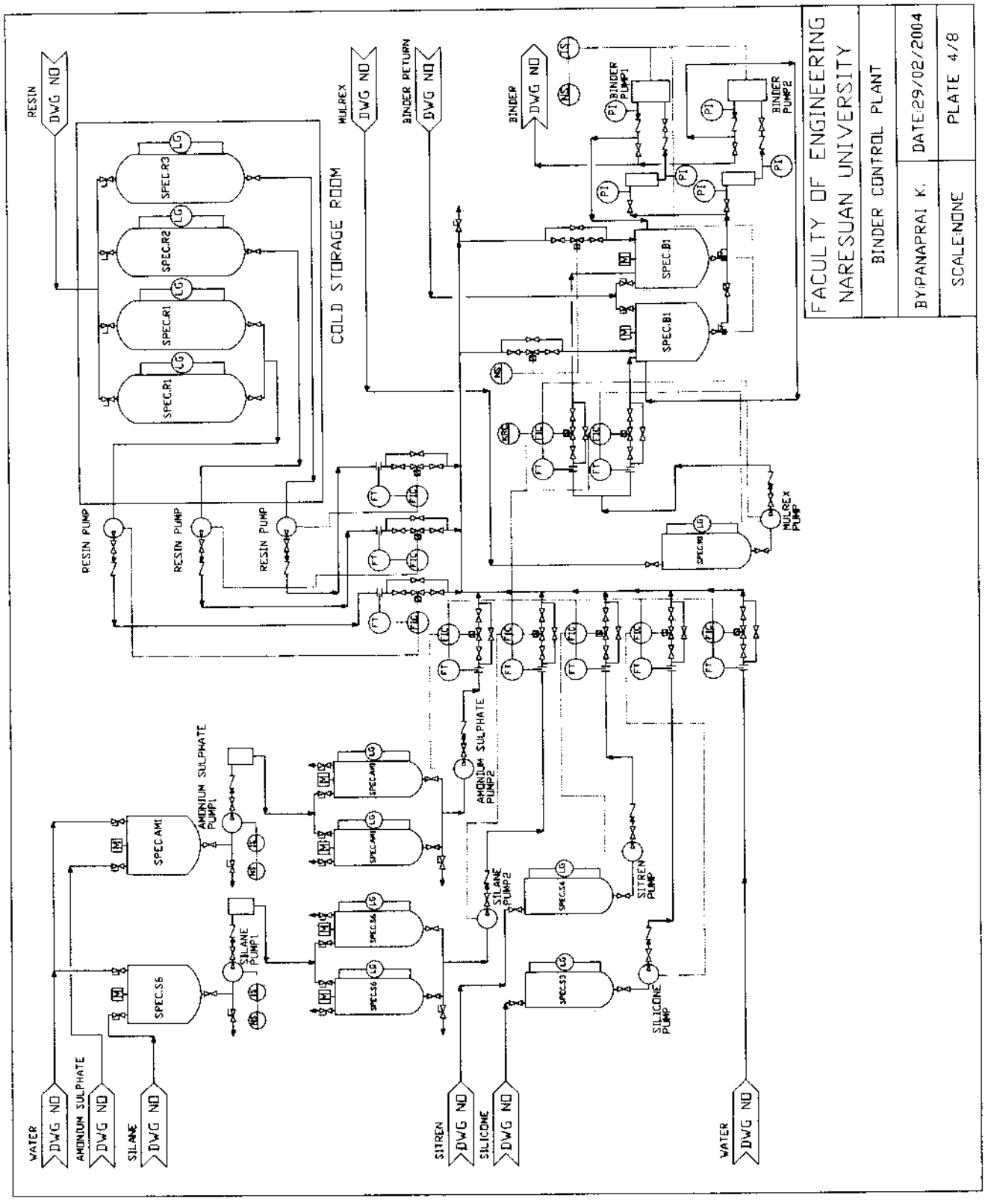
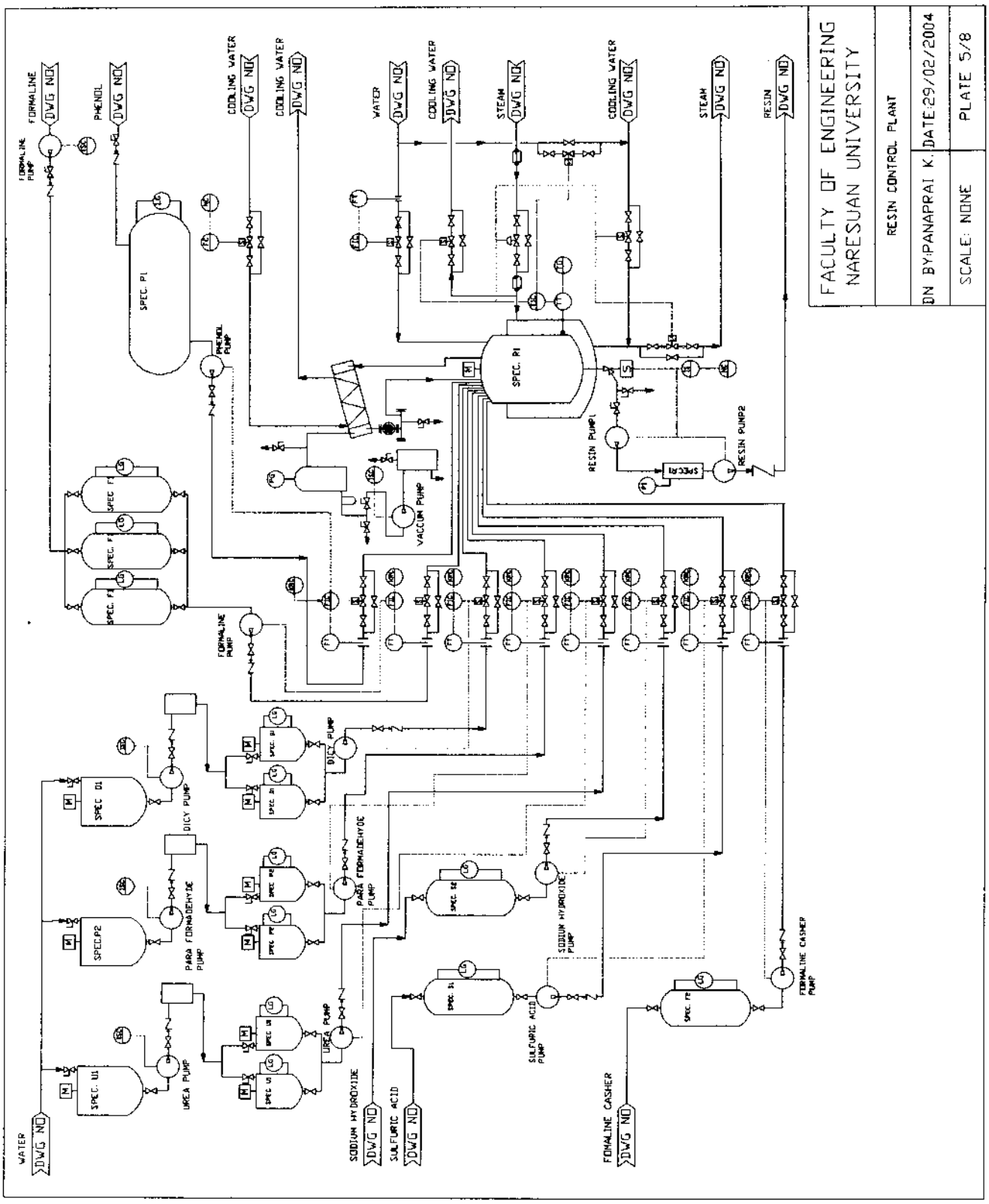
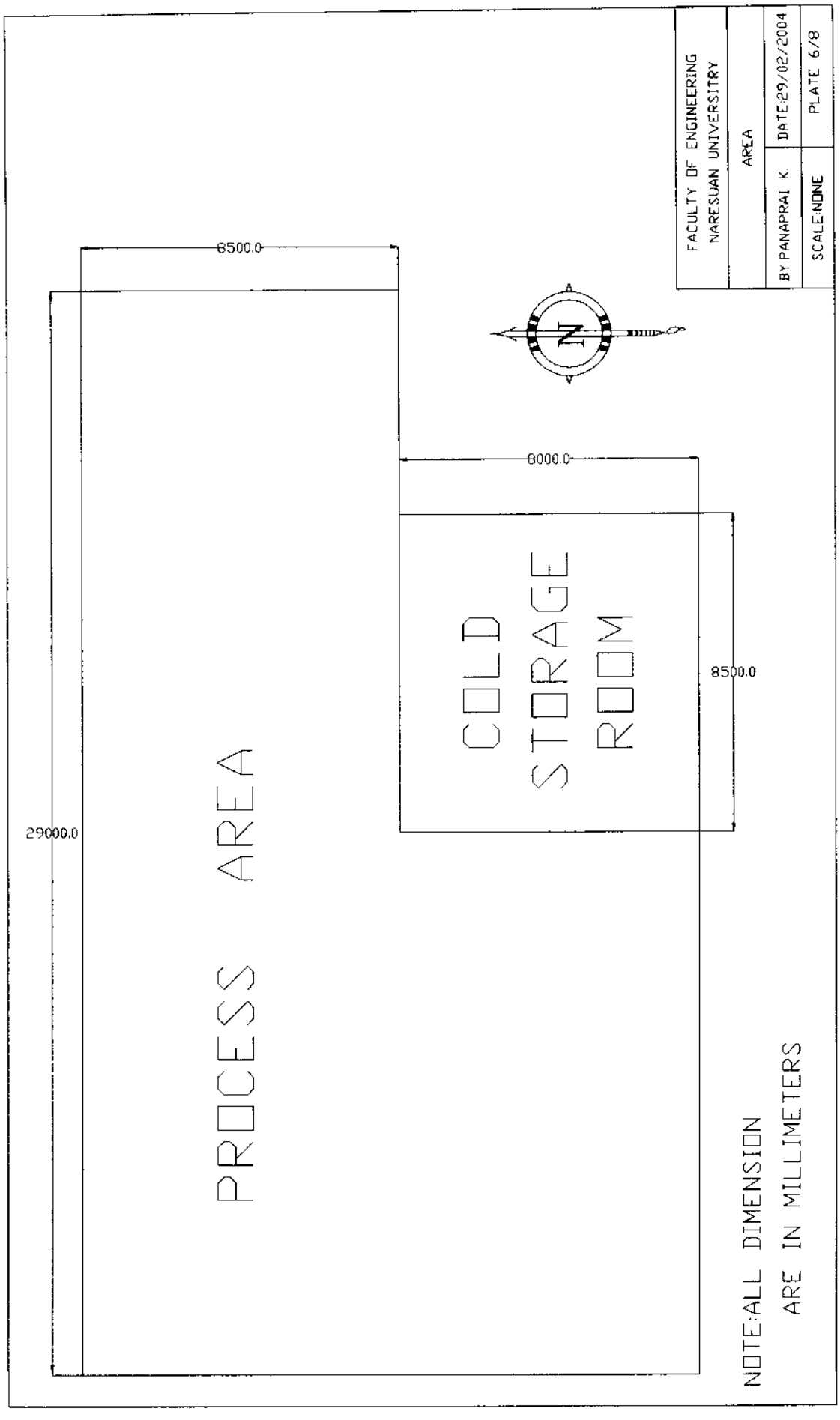
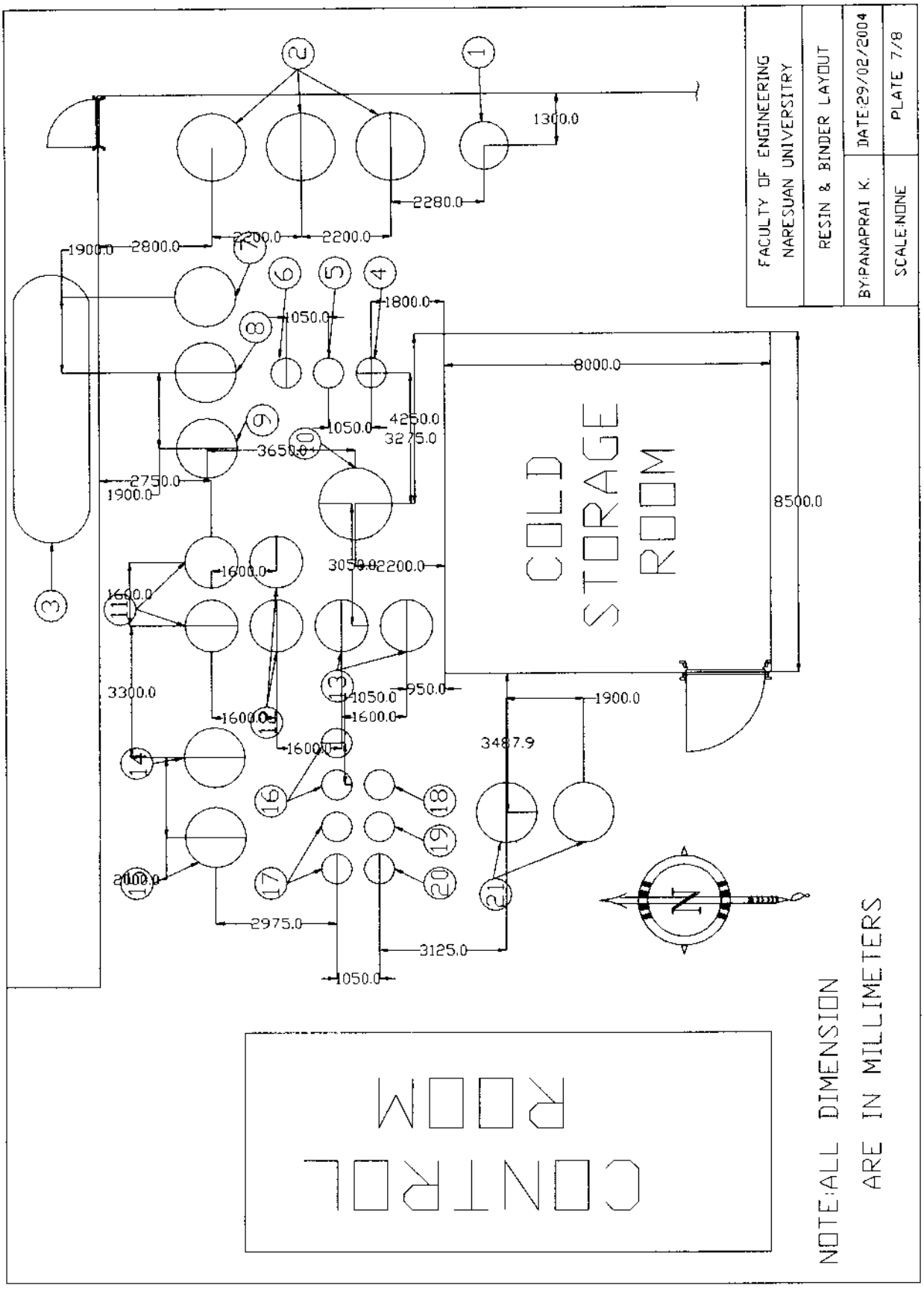
BINDER PLANT
BY:PANAPRAI K.
DATE:29/02/2004
SCALE:NONE
PLATE 3/8
BINDER PLANT
SOLENOID ANGLE VALVE
CONTROL VALVE
FLOW METERS/TRANSMITTER
MANUAL VALVE
SOLENOID VALVE
MIXER TANK V = 3000 LTS.
MIXER TANK V = 3000 LTS.
FILTER
FILTER
PUMP FOR TRANSFERING BINDER TO DISSTRIBUTOR
TO DISSTRIBUTOR
WATER
EXITE
PHENOLIC RESIN
MELAMINE RESIN
HOT MELT RESIN
SILANE SOLUTION V =400 LTS.
SILANE SOLUTION V =400 LTS.
AMMONIUM SULPHATE SOLUTION V =400 LTS.
AMMONIUM SULPHATE SOLUTION V =400 LTS.
STYREN V =400 LTS.
SILICONE V =400 LTS.
MELPEX V =400 LTS.
GEAR MOTOR 1.5Kw 1450 rpm
AIR EXITE
WATER IN
FILTER


FACULTY OF ENGINEERING
NARESUAN UNIVERSITY
BINDER CONTROL PLANT
BY:PANAPRAI K.
DATE:29/02/2004
SCALE:NONE
PLATE 4/8
COLD STORAGE ROOM
RESIN
DWG NO
MULREX
DWG NO
BINDER RETURN
DWG NO
BINDER
DWG NO
SPEC.R1
SPEC.R2
SPEC.R3
RESIN PUMP
MULREX PUMP
SPEC.B1
BINDER PUMP1
BINDER PUMP2
SPEC.AM1
AMONIUM SULPHATE PUMP1
AMONIUM SULPHATE PUMP2
SPEC.S6
SILANE PUMP1
SILANE PUMP2
SPEC.S4
SITREN PUMP
SPEC.S3
SILICONE PUMP
WATER
DWG NO
AMONIUM SULPHATE
DWG NO
SILANE
DWG NO
SITREN
DWG NO
SILICONE
DWG NO
WATER
DWG NO


FACULTY OF ENGINEERING
NARESUAN UNIVERSITY
RESIN CONTROL PLANT
DN BY:PANAPRAI K. DATE:29/02/2004
SCALE: NONE
PLATE 5/8
FORMALINE PUMP
FORMALINE DWG NO
PHENOL
PHENOL DWG NO
COOLING WATER
COOLING WATER DWG NO
WATER
WATER DWG NO
STEAM
STEAM DWG NO
RESIN
RESIN DWG NO
SPEC. P1
PHENOL PUMP
VACCUM PUMP
RESIN PUMP1
RESIN PUMP2
SPEC F1
SPEC F2
SPEC F3
SPEC D1
SPEC D2
DICY PUMP
SPEC P1
SPEC P2
PARA FORMALDEHYDE PUMP
SPEC U1
SPEC U2
UREA PUMP
SPEC S1
SPEC S2
SULFURIC ACID PUMP
SODIUM HYDROXIDE PUMP
SPEC F4
FORMALINE CASHEP PUMP
SODIUM HYDROXIDE DWG NO
SULFURIC ACID DWG NO
FORMALINE CASHER DWG NO


FACULTY OF ENGINEERING
NARESUAN UNIVERSITY
AREA
BY PANAPRAI K.
DATE:29/02/2004
SCALE:NONE
PLATE 6/8
N
8500.0
8000.0
8500.0
29000.0
PROCESS AREA
COLD STORAGE ROOM
NOTE:ALL DIMENSION
ARE IN MILLIMETERS


FACULTY OF ENGINEERING
NARESUAN UNIVERSITY
RESIN & BINDER LAYOUT
BY:PANAPRAI K.
DATE:29/02/2004
SCALE:NONE
PLATE 7/8
COLD STORAGE ROOM
CONTROL ROOM
8000.0
8500.0
1300.0
2280.0
2200.0
1900.0
2800.0
1800.0
1050.0
4250.0
3275.0
3650.0
2750.0
1900.0
3050.0
1600.0
3300.0
950.0
3487.9
2975.0
3125.0
NOTE:ALL DIMENSION
ARE IN MILLIMETERS

ITEM	QTY	NAME
1	1	BOILER
2	3	FORMALIN STRAGE TANK
3	1	PHENOL STORAGE TANK
4	1	SULFURIC ACID STORAGE TANK
5	1	SODIUM HYDROXIDE STORAGE TANK
6	1	FORMALINCATCHER STORAGE TANK
7	1	UREA MIXING TANK
8	1	DICY MIXING TANK
9	1	PARA FORMALDEHYDE MIXING TANK
10	1	REACTOR TANK
11	2	UREA STORAGE TANK
12	2	DICY STORAGE TANK
13	2	PARA FORMALDEHYDE STORAGE TANK
14	1	AMMONIUM SULPHATE MIXING TANK
15	1	SILANE MIXING TANK
16	2	AMMONIUM SULPHATE STORAGE TANK
17	2	SILANE STORAGE TANK
18	1	SITREN STORAGE TANK
19	1	SILICONE STORAGE TANK
20	1	MULREX STORAGE TANK
21	2	BINDER MIXING TANK

FACULTY OF ENGINEERING NARESUAN UNIVERSITRY	
PART LIST	
BY:PANAPRAI K.	DATE:29/02/2004
SCALE:NONE	PLATE 8/8