

PLAINTIFF'S EXHIBIT

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Environmental management • Plant electric systems • Heating and cooling for process and comfort • Mechanical transmission and lubrication • Engines, turbines, generators • Air, gas and liquid handling • Instrumentation and control • Steam generation

1972 PLANT DESIGN ISSUE

Including ☐ Power Environmental Awards
Annual Plant Design Report ☐ 1972 Equipment Roundup

PROJECT	COMPANY	PLANT NAME	LOCATION	CONSULTING ENGINEER	Unit number	Unit capacity, MW	Year of first commercial operation	BOILERS			
								Steam flow, 1000 lb/hr	Superheater outlet pressure, psig	Superheater outlet temp, F	Reheat temp, F
1	Pennsylvania Power Co.	Mansfield	Shippingport, PA	Commonwealth Associates, Inc.	1	900	75	6415	3785	1005	1005
2	Virginia Electric & Power Co.	Yorktown	Hornsbyville, VA	Brown & Root, Inc.	3	345	74	5841	2600	1005	1005
3	Virginia Electric & Power Co.	Possum Point	Dumfries, VA	Brown & Root, Inc.	5	845	76	5841	2600	1005	1005
4	Consolidated Edison Co. of NY, Inc.	Astoria	New York, NY	Ebasco Services Inc.	6	826	74	5864	2450	1005	1005
5	Commonwealth Edison Co.	Powerton	Pekin, IL	Sargent & Lundy	5	818	NAV	5037	2620	1005	1005
6	Appalachian Power Co.	Amos	St. Albans, WV	American Elec Power Service Corp.	2	800	72	5280	3700	1010	1005
7	Detroit Edison Co.	Monroe	Monroe, WI	Self	2	750	72	5718	3800	1000	1000
8	Carolina Power & Light Co.	Roxboro	Roxboro, NC	NAV	4	720	76	5170 ⁵⁶	2610	1005	1005
9	Consumers Power Co.	Karn	Essexville, MI	Commonwealth Associates, Inc.	4	690	75	4650	1890	955	955
10	Northern States Power Co.	Sherburne County	Becker, MN	Black & Veatch	1	680	76	4985	2640	1007	1005
11	Illinois Power Co.	Baldwin	Baldwin, IL	Sargent & Lundy	3	632	75	4220	2620	1005	1005
12	Potomac Electric Power Co.	Chalk Point	Aquasco, MD	United Engineers & Constructors Inc.	4	600	75	4600	1980	953	952
13	Gulf States Utilities Co.	Willow Glen	St. Gabriel, TX	Stone & Webster Engineering Corp.	5	580	74	4035	3850	1005	1000
14	Dallas Power & Light Co.	Monticello	Titus County, TX	Ebasco Services Inc.	1	575	74	4025	3825	1005	1000
15	Wisconsin Power & Light Co.	Columbia	Portage, WI	Sargent & Lundy	1	527	73	3800	2620	1005	1000
16	Iowa Public Service Co.	Neal	Sioux City, IA	Ebasco Services Inc.	3	520	76	3805	2620	1005	1000
17	Northern Indiana Public Service Co.	Kankakee	Wheatfield, IN	Sargent & Lundy	14	520	75	3230	3635	1005	1000
18	The Hydro-Elec Pwr Commn of Ontario	Lennox	Kingston, Ont., Canada	Self	1	513	75	3600	2500	1000	1000
19	Gulf Power Co.	Crist	Pensacola, FL	Southern Services, Inc.	7	500	73	3626	2486	1000	1000
20	The Hydro-Elec Pwr Commn of Ontario	Nanticoke	Port Dover, Ont., Canada	Self	1	500	72	3600	2450	1000	1000
21	Puerto Rico Water Resources Auth.	South Coast	Guaynilla, PR	United Engineers & Constructors Inc.	5	450	72	2970	2400	1000	1000
22	Tampa Electric Co.	Big Bend	Tampa, FL	Stone & Webster Engineering Corp.	3	450	75	3116	2552	1000	1000
23	Puerto Rico Water Resources Auth.	Aguirre	Guayama, PR	United Engineers & Constructors Inc.	1	450	74	3170	2400	1000	1000
24	Utah Power & Light Co.	Huntington Canyon	Huntington, UT	Sterns-Roger Corp.	2	440	74	2965	2400	1000	1000
25	Central Louisiana Electric Co. Inc.	Rodemacner	Vic of Boyce, LA	Sargent & Lundy	1	430	75	3025	2400	1000	1000
26	Delmarva Power & Light Co.	Edge Moor	Edge Moor, DE	Bechtel Corp.	5	410	73	2890	2460	1000	1000
27	Philadelphia Electric Co.	Eddystone	Eddystone, PA	United Engineers & Constructors Inc.	3	400	74	2850	1980	950	950
28	Long Island Lighting Co.	Northport	Northport, NY	Ebasco Services Inc.	4	380	75	2550	2640	1005	1000
29	Central Illinois Light Co.	Duck Creek	Vic of Canton, IL	Commonwealth Associates, Inc.	1	370	76	3000	2600	1005	1000
30	Public Service Co. of New Mexico	San Juan	Waterflow, NM	Sterns-Roger Corp.	1	370	73	2600	1900	1000	1000
31	Montana Power Co.	Colstrip	Colstrip, MT	Bechtel Corp.	1	350	75	2520	2597	1005	1000
32	Jersey Central Power & Light Co.	Gilbert	Millford, NJ	Burns and Roe, Inc.	1	316 ¹⁴	73 ¹⁵	250 ¹⁵	1350	955	N
33	South Carolina Public Service Auth.	Georgetown	Georgetown, SC	Burns and Roe, Inc.	1	303	74	2100	2400	1005	1000
34	San Diego Gas & Electric Co.	Encina	Carlsbad, CA	Pioneer Service & Engineering Co.	4	300	73	2050	1890	950	950
35	Public Service Co. of Oklahoma	Comanche	Lawn, OK	Westinghouse Electric Corp.	1	240 ⁶³	73	443 ⁶⁶	1360	950	N
36	Southwestern Public Service Co.	Jones	Lubbock, TX	Self	2	235	74	1783	1940	1005	1000
37	Central Illinois Public Service	Meredosa	Meredosa, IL	Sargent & Lundy	4	195	75	1425	2500	1005	1000
38	Atlantic City Electric Co.	England	Beesleys Point, NJ	United Engineers & Constructors Inc.	3	160	74	1260	1940	1005	1000
39	West Texas Utilities Co.	Fort Phantom	Abilene, TX	Trippett and Gee, Consulting Engrs	1	146	74	1059	1865	1005	1000
MUNICIPAL AND COOPERATIVE INSTALLATIONS											
40	Basin Electric Power Coop.	Olds	Stanton, ND	Burns and Roe, Inc.	2	450	75	3050	2640	1005	1000
41	San Antonio Public Service Board	Sommers	Elmendorf, TX	Black & Veatch	3	436	76	3054	2620	1005	1000
42	East Kentucky Rural Electric Coop.	Charlestown Bottoms	Maysville, KY	Stanley Consultants, Inc.	1	200	75	2300	2610	1005	1000
43	Braxos Electric Power Coop.	Muler	Palo Pinto, TX	Trippett & Gee, Consulting Engrs	3	200	75	1550	1977	1005	1000
44	Taunton Municipal Lighting Plant	Clearly	Taunton, MA	Paul L. Gerringer & Associates	9	110 ⁵⁰	73	557	1875	1005	1000
45	Fremont Dept. of Utilities	Wright	Fremont, NE	Lutz, Daily & Brain	8	92	76	675	1800	1005	1000
46	Alexandria Munic. Power & Light Dept.	Hunter	Alexandria, LA	Black & Veatch	4	85	73	718	1350	955	950
47	Denton Municipal Utilities	Denton	Denton, TX	Black & Veatch	5	65	73	580	1250	955	950
48	Vero Beach Municipal Power Plant	Vero Beach	Vero Beach, FL	Black & Veatch	4	55	75	505	1350	955	950

MANUFACTURERS

AC - Allis-Chalmers Manufacturing Co.
ACP - Allis-Chalmers Power Systems, Inc.
APC - The Air Preheater Co., Inc.
AS - American Standard, Inc.
BB - Brown Boveri Corp.
BF - Buffalo Forge Co.
BLJ - Byron-Jackson Pumps, Div Borg-Warner Corp.
BLH - Baldwin Hamilton Co.
BM - Bailey Meter Co.
BPC - Bingham Pump Co.
BRP - Bruce Peebles & Co., Ltd.
BU - Buell Engineering Co., Inc.
BW - Babcock & Wilcox Co.
BWL - Babcock & Wilcox Ltd.
CAP - C. A. Parsons, Ltd.
CE - Combustion Engineering, Inc.
CES - Combustion Energy Superheater Co., Ltd.
CHH - Chicago Heater Co.
CIR - Canadian Ingersoll-Rand Co. Ltd.
COC - Cochrane Div, Crane Co.
CRL - Croil-Reynolds Engineering Co., Inc.
CUL - Culligan Industrial Systems Div, Culligan USA.
CV - Copes-Vulcan, Inc.
DL - DeLaval Turbine Inc.
OP - Diamond Power Specialty Corp.
EAI - Electronics Associates, Inc.

EE - English Electric Co. Ltd.
EL - Ecodyne Ltd.
EM - Electric Machinery Manufacturing Co.
F - The Foxboro Co.
FIS - Fischer & Porter Co.
FO - Forney Engineering Co.
FW - Foster Wheeler Corp.
GDI - Gulf Degemont, Inc.
GE - General Electric Co.
GF - The Green Fuel Economizer Co.
GW - The Gravel Water Conditioning Co.
HAP - James Howden & Parsons of Canada Ltd.
HCC - Computer and Instrumentation Div, Westinghouse Electric Corp.
HOW - Howell Instruments, Inc.
HT - Hungerford & Terry, Inc.
IBM - International Business Machines Corp.
IN - Inflico Products Co.
IR - Ingersoll-Rand Co.
IW - Illinois Water Treatment Co.
JOY - Joy Manufacturing Co.
KKK - Kuhnle, Kopp & Kausch-AG.
LA - The Louis Allis Co., Inc.
LAW - LA/Water Treatment Div, Chromalloy American Co.
LN - Leeds & Northrup Co.
LOD - Lodge-Cottrell Ltd.
MLW - MLW Worthington Ltd.
MR - Milton Roy Co.

MS - Maryland Shipbuilding & Drydock Co.
NOV - Novenco Inc.
PEC - Peabody Engineering Corp.
PM - The Permunit Co.
PP - Pacific Pumps Div, Dresser Industries Inc.
RA - Raymond Div, Combustion Engineering, Inc.
RS - Riley Stoker Corp.
SIE - Siemens AG.
STW - Struthers-Wells Corp.
SWE - Southwestern Engineering Co.
WE - Westinghouse Electric Corp.
WM - The Whitlock Manufacturing Co.
WO - Worthington Co.
YU - Yuba Heat Transfer Corp.
ZU - Air Systems Div, Zurn Industries, Inc.

SYMBOLS

ABr - Aluminum bronze
Ad - Admiralty brass
Adi - Admiralty, inhibited
AlB - Aluminum brass
AnC - Analog computer
Att - Attenuator
BA - Bladed airfoil
Bal - Balanced
BC - Backward-curved blades
BD - Balanced draft
C - Coal, bituminous

Cir - Circular
Cr - Crude oil
CuN - Copper/nickel
Cy - Cyclone
D - Damper
DB - Dry bottom
De - Demineralizer
D/C - Digital computer
D/O - Distillate oil
EA - Excess air
Eva - Evaporator
Fs - Fuel in storage
Fub - Fuel at burner
G - Gas
GR - Flue-gas recirc.
Gt - Gas tempering
H2 - Hydrogen
H2O - Water
HF - Horizontal flue
HI - Horizontal mt
Hyb - Hybrid
HyC - Hydraulic cou.
J - Steam jet effec.
L - Lignite
M - Motor
MAN - Monitoring
MAP - Monitoring, partial control
MgO - Magnesium oxide

plants and general list power in 1973

Project	BOILERS										FURNACE										FORCED DRAFT FANS																			
	Surface, 1000 sq ft										Burners										Pulverizers										Drive									
	Boiler and waterwalls	Superheater	Reheater	Economizer	Air heater	Pressure, in H ₂ O	Volume, 1000 cu ft	Conduction rate, 1000 Btu/hr cu ft	Type	Number per boiler	Type	Manufacturer	Number per boiler	Capacity of each, ton/hr	Manufacturer	Number per boiler	Capacity of each, 1000 cfm	Wheel type	Flow control	Manufacturer	Type	Number per boiler	Hp each	Manufacturer																
Art, TB	111	156	199	236	1022	-0.1	734	10.8	BD	32	HI	FW	8	55	FW	2	1250	BA	V	NAV	M	2	NAV	NAV	1															
	72	133	222	276	245	0.1	383	20.5	BD, DB	32	CE	N				2	880	BC	V	WE	M	2	4500	GE	2															
	72	133	222	376	245	-0.1	383	20.5	BD, DB	32	CE	N				2	880	BC	V	WE	M	2	4500	GE	3															
	47	143	156	344	687	0.1	467	NAV	BD, DB	36	NAV	FO	N			2	1075	BC	V, D	APC	M	2	6000	EE	4															
	65	113	111	60	496	0.2	271	NAV	BD	10	CY	BW	N			2	522	BC	NAV	BF	M	2	6000	GE	5															
Art, D	84	64		236	627	18	480	14.6	Prd, DB	36	Cir	FW	6	60	FW	2	1000	BA	V	WE	M	2	7000	EE	6															
	39	226	206	283	1815	-0.1	469	15	BD	28	PC	BW	7	50	BW	2	1062	BA	V	GF	M	2	2500	AC	7															
	50	82	54	50	442	NAV	200	NAV	BD, DB	24	HF	RS	6	23	RS	1	721	BA	V, D	AS	M	1	2320	WE	8															
	52	77	31	532	N	0.1	241	28	BD	30	HF	FO, RS	N			2	825	BA	V	WE	M	2	3000	NAV	9															
	NAV	119	50	230	972	0.1	540	12.5	BD, DB	56	TB	CE	N	72	RA	2	679	BA	V	WE	M	2	NAV	NAV	10															
Art, TB	77	100	48	363	748	-0.5	516	10.8	BD	24	TB	CE	6	66	RA	3	380	BA	V	WE	M	3	1500	NAV	11															
	NAV	78	44	301	153	NAV	253	NAV	BD	32	TB	CE	N			2	763	BA	V	AS	M	2	4000	WE	12															
	NAV	NAV	NAV	NAV	402	35.8	NAV	25.4	Prd, DB	26	NAV	CE	N			2	650	NAV	V, D	CE	M	2	5000	EM	13															
	56	116	135	65	695	0.15	512	11.1	BD, DB	64	NAV	CE	8	72	CE	2	455	BA	V	WE	M	2	1250	WE	14															
	71	82	46	190	746	-0.3	421	12.2	BD, ST	24	TB	CE	6	69	CE	2	462	BA	V	WE	M	2	1750	LA	15															
Art, D	30	79	119	185	755	0.1	334	15	BD, DB	24	HI	FW	6	48	FW	2	575	BA	V, D	AS	M	2	3500	GE	16															
	90	111	97	95	321	-0.1	266	16.2	BD, ST	10	CY	BW	N			2	607	NAV	V	NAV	M	2	8000	NAV	17															
	26	160	27	135	402	-0.15	157	30.7	BD	32	CE	N				2	534			NOV			2300	NAV	18															
	26	36	113	154	44	20	282	16.8	Prd	24	HI	FW	6	32.9	FW	2	545	BA	V, S	AS	M	2		WE	19															
	51	123	108	151	464	0.1	251	19.9	BD, DB	40	Cir		5		BWL	2	528			HAP			1450	SIE	20															
Art, TB, WS	32	115	151	100	369	0.15	240	16.5	BD, DB	16	TB	CE	N			2	558	NAV	V	WE	M	2	1750	AC	21															
	53	101	73	71	370	13.4	243	17.5	Prd	24		PEC	N			2	2286	BA	NAV	WE	M	2	4500	EM	22															
	32	100	160	88	369	0.15	240	17.4	BD, DB	16	TE	CE	N			2	559	NAV	V	WE	M	2	1750	AC	23															
	NAV	117	45	240	229	-0.1	319	12.1	BD	20	TB	CE	5	44	RA	2	665	BC	V	WE	M	2	2250	GE	24															
	18	90	30	68	302	37	115	NAV	Prd	24	Cir	BW	N			2	470	BA	V	WE	M	2	5000	WE	25															
Art, GR	44	146	40	74	350	0.1	137	27.5	BD	28	Cir	BW	N			2	408	BA	V	WE	M	2	2000	WE	26															
	30	43	23	238	101	8.1	159	26.5	BD, DB	16	TB	CE	N			2	476	BA	V	WE	M	2	2000	WE	27															
	71	61	89	146	295	-0.5	231	14.9	BD	16	TB	CE	N			2	333	BA	V	NAV	M	2	1500	NAV	28															
	52	117	79	54	582	0.1	270	13.9	BD	24	HF	RS	3	64.8	RS	2	1151	NAV	V, D	NAV	M	2	1750	NAV	29															
	88	56	101	129	444	11.6	290	12	Prd	16	NAV	FO	4	50	FW	2	1000			V	WE	M	2	4000	GE	30														
Art, WS	45	59	29	153	250	-0.1	236	14.3	BD, DB	20	TB	CE	5	53	RA	2	626	BA	V, D	WE	M	2	2500	WE	31															
	91	29	71	71	N																				32															
	40	NAV	NAV	41	243	-0.3	175	15.9	BD, DB	24	HF	RS	6	25.5	RS	2	272	BA	V	ZU	M	2	1250	NAV	33															
	36	26	29	58	142	19.5	87	35	Prd	24	NAV	BW	N			2	415	BA	V, D	WE	M	2	4000	GE	34															
	174	67	N	268	0						NAV		N												35															
Art, TB	22	33	17	104	278	17	94		Prd	16		CE	N			2	314	NAV	HvC	APC					36															
	25	47	15	53	135	27	71	26.5	Prd, DB	8	NAV	FO	N			2	230	BC	V	WE	M	2	2250	WE	37															
	9	27	9	72	86	-0.1	58.4	29	BD, DB	12	TB	CE	N			2		BA	V	WE	M	2	900	WE	38															
	17	26	10	53	167	12.5	44	33.3	Prd	6	HF	PEC, RS	N			1	302	BA	V	AS	M	1	3000	WE	39															
Art, GR	50	136	69	95	1131	NAV	404	12.1	BD	12	CY	BW	NAV			2	530	BA	D	WE	M	2	8000	AC	40															
	NAV	54	62	221	343	30	162	NAV	Prd	16	TB	CE	N			2	488	BA	V	WE	M	2	4000	GE	41															
	36	134	54	57	N	30	210	NAV	NAV	24	NAV	BW	8	21.5	BW	2	NAV	NAV	S	NAV	M	2	1500	NAV	42															
	22	33	15	80	321	12	76	28	Prd	9	HF	RS, PEC	N			2	252	NAV	V	BF	M	2	1500	NAV	43															
	46	13	21	70	N	11.8	27	31	Prd	9	HF	RS	N			151	NAV	NAV	NAV	NAV	M				44															
Art, GR	24	42	13	10	89	13.2	NAV	NAV	BD	9	NAV	BW	3	48	BW	1	931			V	NAV	M	1	750	NAV	45														
	10	0	N	N	87	20	33.3	27	Prd	6		NAV	CE	N			1	260	BA	HvC, D	AS	M	1	2000	WE	46														
	30	7	N	N	87	20	33	33.8	Prd	6	NAV	CE	N			1	208	BA	D	APC	M	1	800	AC	47															
	22	9	N	N	54	15	22.5	26.2	Prd	6	NAV	FO	N			1	173	BA	HvC	GF	M	1	1750	WE	48															

1. Jointly owned with Texas Electric Service Co and Texas Power & Light Co

2. Acting on its own behalf and as agent for Cleveland Electric Illuminating Co, Duquesne Light Co, Ohio Edison Co, Toledo Edison Co and Pennsylvania Power Co

3. Primary, 53,000 sq ft; secondary, 411,000

4. Opposed firing - 24 burners in front wall, 16 in rear wall

5. pH control: morpholine injection

6. Single-cylinder turbine

7. Data are for the main feedpump. There are also two 35% capacity pumps, each with 5300-hp motor drives manufactured by SIE

8. Base-load, indoor unit unless otherwise specified

9. Variable-pitch fan blades

10. Axial-flow fan

11. Units are Imperial gpm

12. Units are feet

13. Total output of four gas turbines (rated 47.5 each) and one steam turbine that are packaged together in a preengineered combined-cycle plant. For data on the combustion turbines, see p S-12

14. Gas turbines will be installed in 1973; the steam turbine in 1974

15. Jointly owned with Wisconsin Public Service Corp and Madison Gas & Electric Co

16. Jointly owned with Iowa Power & Light Co, Iowa Southern Utilities Co and Iowa Illinois Gas and Electric Co

17. Control firing rate

18. Also dampers

19. Gross rating

20. pH control: ammonia injection

21. Primary steam source, main unit crossover; secondary steam source, main steam

22. High-pressure/low-pressure

23. Gross heat rate at 100% load with exhaust pressure of 1.5 in. Hg abs

24. Performance fuel

25. Wide-range mechanical burners

26. pH control: cyclohexylamine injection

27. Applies to data logger

28. Data are for the main feedpump. Standby pump, manufactured by IR, is rated 5150 gpm at 3272 psig. It is driven by a 10,000-hp motor manufactured by BB

29. Units are 1000 Btu/gal

30. Peaking/cycling unit

31. Outdoor unit

32. Condensing unit

33. DsO, 136,000 Btu/gal; RsO, 145,000 Btu/gal; G, 1030 Btu/cu ft

34. DsO, 0.16; RsO, 0.3; G, 0

35. Data are for the main feedpumps. Two standby pumps, manufactured by BJ, have

36. HvC for flow control. Each is driven by a 10,000-hp motor manufactured by GE

37. pH control: hydrazine injection

38. L-p heaters are arranged in a parallel-series circuit. Two trains of two heaters each operate in parallel. Discharge from both trains is combined and flows to two l-p heaters arranged in series. One of these heaters is closed, one is open

39. Twin-shell unit with arsenical-copper tubes in the condensing section and CuN tubes in the air-removal section

40. Assumes valves wide open, 5% overpressure and 1 in. Hg abs vacuum in the main unit

41. Primary steam source, second reheater; secondary steam source, first reheater and auxiliary boiler

42. Turbine heat rate

43. Primary steam source, main turbine bleed; secondary steam source, main steam

44. DsO, 19,847 Btu/lb; G, 1000 Btu/cu ft

45. In DsO

46. Excess-air control

47. Semi-outdoor unit

48. DsO, 19,500 Btu/lb; RsO, 18,400 Btu/lb; G, 1000 Btu/cu ft

49. Assumes natural-gas firing and turbine exhausting at 1.5 in. Hg abs

Fossil-fired Central Stations

New peaking/cycling plant

Each project listing covers four pages

PROJECT	INDUCED-DRAFT FANS								TURBINE ⁷¹			CONDENSER					FEEDWATER					CONTROLS		
	Number per boiler	Capacity of each, 1000 cfm	Flow control	Manufacturer	Drive			Exhaust pressure, in. Hg abs	Number of bleed points	Number of exhausts	Manufacturer	Surface area, 1000 sq ft	Number of water passes	Tube material	Manufacturer	Air removal equipment	Makeup treatment	Condensate treatment	Treatment system manufacturer, makeup/condensate	Combustion (Mfr)	Feedwater (Mfr)	Closed-circuit TV (Mfr)		
					Type	Number per boiler	Hp each																Manufacturer	
1	NAV	NAV	NAV	NAV	NAV	NAV	NAV	1.5	8	5	GE	370	1	Ad	IR	Ro	De	De ²¹	NAV/GW	BM	BM	N		
2	4	694	D	AS	M	4	6000	AC	1.5	7	5	GE	483	1	Ad	IR	J	De	NAV	HCC	HCC	DP		
3	4	694	D	AS	M	4	6000	AC	1.5	7	5	GE	483	1	Ad	IR	J	De	NAV	HCC	HCC	DP		
4	3	1190	D	APC	M	3	7000	EE	2	7	4	WE	356	1	ABr	IR	Ro	De	NAV	GE, FO	BM	NAV		
5	2	326	HvC	BF	M	2	5000	GE	3.5	7	6	GE	450	1	SSt	WE	J	De	De	BM	BM	DP		
6	N	1408	V	GF	M	2	5500	AC	1.5	7	4	GE	360 ³⁹	1	Ad	IR	Ro	De	NAV	HCC	HCC	DP		
7	2	1088	V, D	AS	M	1	4750	WE	2.5	7	4	WE	301	1	Ad	IR	Ro	De	NAV	HCC	HCC	NAV		
8	1	1600	V	WE	M	2	7000	NAV	3	5	4	ACP	295	1	CuN	DL	Ro	De	NAV	HCC	HCC	NAV		
9	2	665	D	GF	M	4	NAV	NAV	1.5	NAV	4	GE	332	1	SSt	FW	Ro	De	NAV	NAV	NAV	NAV		
10	4	665	D	GF	M	4	NAV	NAV	1.5	NAV	4	GE	332	1	SSt	FW	Ro	De	NAV	NAV	NAV	NAV		
11	3	770	HvC	WE	M	3	4000	NAV	1.5	7	4	GE	310	1	SSt, CuN	IR	Ro	De	NAV	NAV	NAV	NAV		
12	4	1210	HvC, D	NAV	M	4	7000	WE	4	4	1	GE	414	2	CuN	IR	Ro	De	NAV	NAV	NAV	NAV		
13	N	1241	D	APC	M	2	4000	WE	2.5	7	4	WE	210	1	SSt	FW	Ro	De	NAV	NAV	NAV	NAV		
14	2	999	HvC	BF	M	2	6900	WE	1	7	4	GE	250	2	Ad	WE	Ro	De	NAV	NAV	NAV	NAV		
15	2	828	S	AS	M	2	6000	GE	1.5	7	2	GE	460	2	SSt	IR	Ro	De	NAV	NAV	NAV	NAV		
16	2	1000	HvC	NAV	M	2	7000	NAV	1.5	7	4	WE	300	1	SSt, Ad	WE	Ro	De	NAV	NAV	NAV	NAV		
17	3	743	V	KKK	M	2	3500	NAV	1.5	7	4	GE	160	1	Ad	FW	J	De	NAV	NAV	NAV	NAV		
18	N	800	V	HAP	M	2	3000	BRP	1.5	7	4	CAP	163	1	Ad, CuN	BLH	Ro	De	NAV	NAV	NAV	NAV		
19	N	800	V	HAP	M	2	3000	BRP	1.5	7	4	CAP	163	1	Ad	MLW	Ro	De	NAV	NAV	NAV	NAV		
20	2	879	V	WE	M	2	4500	GE	2	7	2	GE	248	1	Ad	BLH	Ro, J	De	NAV	NAV	NAV	NAV		
21	2	879	V	WE	M	2	4500	GE	2	7	2	GE	248	1	Ad	BLH	Ro, J	De	NAV	NAV	NAV	NAV		
22	2	390	V	WE	M	2	4500	GE	2.5	7	2	BB	248	1	Ad	BLH	Ro, J	De	NAV	NAV	NAV	NAV		
23	2	390	V	WE	M	2	4500	GE	2.5	7	2	BB	248	1	Ad	BLH	Ro, J	De	NAV	NAV	NAV	NAV		
24	2	1105	D	WE	M	2	4500	GE	1.5	6	2	GE	171	2	SSt, Ad	SWE	J	De	NAV	NAV	NAV	NAV		
25	N	1105	D	WE	M	2	4500	GE	1.5	6	2	GE	171	2	SSt, Ad	SWE	J	De	NAV	NAV	NAV	NAV		
26	2	525	D	WE	M	2	4500	WE	2	7	2	WE	218	1	Ad	DL	Ro	De	NAV	NAV	NAV	NAV		
27	2	754	D	AS	M	2	6000	WE	2	3	1	WE	178	1	Ad	IR	J	De	NAV	NAV	NAV	NAV		
28	2	489	D	NAV	M	2	3500	NAV	1.6	7	4	GE	130	1	NAV	IR	Ro	De	NAV	NAV	NAV	NAV		
29	4	NAV	NAV	NAV	NAV	NAV	NAV	NAV	3.5	8	2	GE	212	1	SSt, Ad	DL	Ro	De	NAV	NAV	NAV	NAV		
30	N	NAV	NAV	NAV	NAV	NAV	NAV	NAV	2.3	6	2	WE	165	2	Ad	DL	J	De	NAV	NAV	NAV	NAV		
31	2	NAV	D	NAV	M	2	NAV	NAV	3.5	6	2	GE	144	2	SSt, Ad	DL	J	De	NAV	NAV	NAV	NAV		
32	N	NAV	D	NAV	M	2	NAV	NAV	3.5	6	2	GE	79	2	Ad	CuN	IR	NAV	NAV	NAV	NAV	NAV		
33	2	413	D	ZU	M	2	2250	NAV	2	6	2	GE	148	1	Ad	DL	Ro	De	NAV	NAV	NAV	NAV		
34	N	NAV	D	NAV	M	2	NAV	NAV	1.5	3	2	WE	103	1	CuN	WE	Ro	De	NAV	NAV	NAV	NAV		
35	N	NAV	D	NAV	M	2	NAV	NAV	NAV	1	1	WE	98	2	Ad	WE	J	De	NAV	NAV	NAV	NAV		
36	N	NAV	D	NAV	M	2	NAV	NAV	NAV	1	1	WE	98	2	Ad	WE	J	De	NAV	NAV	NAV	NAV		
37	N	NAV	D	NAV	M	2	NAV	NAV	NAV	1	1	WE	98	2	Ad	WE	J	De	NAV	NAV	NAV	NAV		
38	2	NAV	V	AS	M	2	2000	GE	1.5	6	2	GE	30	2	CuN	DL	Ro	De	NAV	NAV	NAV	NAV		
39	N	NAV	V	AS	M	2	2000	GE	1.5	6	2	GE	30	2	CuN	DL	Ro	De	NAV	NAV	NAV	NAV		
40	N	NAV	V	AS	M	2	2000	GE	1.5	6	2	GE	30	2	CuN	DL	Ro	De	NAV	NAV	NAV	NAV		
41	N	NAV	V	AS	M	2	2000	GE	1.5	6	2	GE	30	2	CuN	DL	Ro	De	NAV	NAV	NAV	NAV		
42	N	NAV	V	AS	M	2	2000	GE	1.5	6	2	GE	30	2	CuN	DL	Ro	De	NAV	NAV	NAV	NAV		
43	N	NAV	V	AS	M	2	2000	GE	1.5	6	2	GE	30	2	CuN	DL	Ro	De	NAV	NAV	NAV	NAV		
44	N	NAV	V	AS	M	2	2000	GE	1.5	6	2	GE	30	2	CuN	DL	Ro	De	NAV	NAV	NAV	NAV		
45	1	1012	D	NAV	M	2	52	NAV	2.5	6	2	GE	60	2	Ad	SWE	J	De	NAV	NAV	NAV	NAV		
46	N	NAV	D	NAV	M	2	NAV	NAV	2.5	6	2	GE	60	2	Ad	SWE	J	De	NAV	NAV	NAV	NAV		
47	N	NAV	D	NAV	M	2	NAV	NAV	2.5	6	2	GE	60	2	Ad	SWE	J	De	NAV	NAV	NAV	NAV		
48	N	NAV	D	NAV	M	2	NAV	NAV	2.5	6	2	GE	60	2	Ad	SWE	J	De	NAV	NAV	NAV	NAV		

MANUFACTURERS

AC - Allis Chalmers Manufacturing Co
ACP - Allis Chalmers Power Systems, Inc
APC - The Air Preheater Co, Inc
AS - American Standard, Inc
BB - Brown Boveri Corp
BF - Buffalo Forge Co
BJ - Byron-Jackson Pumps, Div Borg-Warner Corp
BLH - Baldwin-Hamilton Co
BM - Bailey Meter Co
BPC - Bingham Pump Co
BRP - Bruce Peebles & Co, Ltd
BU - Buell Engineering Co, Inc
BW - Babcock & Wilcox Co
BWL - Babcock & Wilcox Ltd
CAP - C/A Parsons, Ltd
CE - Combustion Engineering, Inc
CES - Combustion Engineering Superheater Co, Ltd
CHH - Chicago Heater Co
CIR - Canadian Ingersoll-Rand Co Ltd
COC - Cochrane Div, Crane Co
CRL - Croil-Reynolds Engineering Co, Inc
CUL - Culligan Industrial Systems Div, Culligan USA
CV - Copes Vulcan, Inc
DL - DeLaval Turbine Inc
DP - Diamond Power Specialty Corp
EAI - Electronics Associates, Inc

EE - English Electric Co Ltd
EL - Ecodyne Ltd
EM - Electric Machinery Manufacturing Co
F - The Foxboro Co
FIS - Fisher & Porter Co
FW - Forney Engineering Co
GF - Foster Wheeler Corp
GDI - Gulf Development, Inc
GE - General Electric Co
GE - The Green Fuel Economizer Co
GW - The Grover Water Conditioning Co
HAP - James Howden & Parsons of Canada Ltd
HCC - Computer and Instrumentation Div, Westinghouse Electric Corp
HOW - Howell Instruments, Inc
HT - Hungerford & Terry, Inc
IBM - International Business Machines Corp
IN - Infilco Products Co
IR - Ingersoll-Rand Co
IW - Illinois Water Treatment Co
JOY - Joy Manufacturing Co
KKK - Kuhnle, Kopp & Kausch AG
LA - The Louis Allis Co, Inc
LAW - LA/Water Treatment Div, Chromalloy American Co
LN - Leeds & Northrup Co
LDD - Lodge-Cortrell Ltd
MLW - MLW Worthington Ltd
MR - Milton Roy Co

MS - Maryland Shipbuilding & Drydock Co
NOV - Novenco Inc
PEC - Peabody Engineering Corp
PM - The Permutit Co
PP - Pacific Pumps Div, Dresser Industries Inc
RA - Raymond Div, Combustion Engineering, Inc
RS - Riley Stoker Corp
SIE - Siemens AG
STW - Struthers-Wells Corp
SWE - Southwestern Engineering Co
WE - Westinghouse Electric Corp
WM - The Whitlock Manufacturing Co
WO - Worthington Corp
YU - Yuba Heat Transfer Corp
ZU - Air Systems Div, Zurn Industries, Inc

SYMBOLS

ABr - Aluminum bronze
Ad - Admiralty brass
Adl - Admiralty, inhibited
AIB - Aluminum brass
AnC - Analog computer
Att - Attenuator
BA - Bladed airflow
Bal - Balanced
BC - Backward-curved blades
BO - Balanced draft
C - Coal, bituminous

Cir - Circular
Cr - Crude oil
CuN - Copper/nickel
Cy - Cyclone
D - Damper
DB - Dry bottom
De - Demineralization
DIC - Digital computer
DO - Distillate oil
Ea - Excess air
Eva - Evaporator
Fs - Fuel in storage
Fub - Fuel at burner
G - Gas
GR - Flue-gas recirculation
Gt - Gas tempering
H2 - Hydrogen
H2O - Water
HF - Horizontal flare burner
HI - Horizontal interseal
Hyb - Hybrid
HvC - Hydraulic coupling
J - Steam jet ejector
L - Lignite
M - Motor
MAN - Monitoring and analysis
MAP - Monitoring, analysis and partial control
MgO - M. magnesium oxide

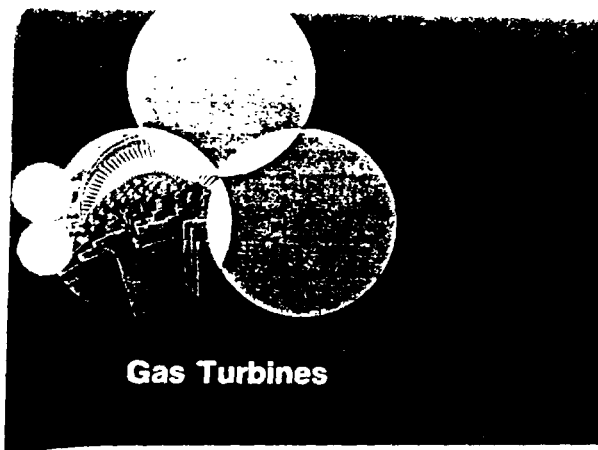
BOILER FEED PUMPS										FEEDWATER HEATERS				FUEL AND EXHAUST										PROJECT
Application	Number per boiler	Capacity of each gpm	Discharge pressure, psig	Manufacturer	Flow control	Drive			Number of heater trains	Number of closed heaters per train	Final feedwater temp F	Manufacturers	Type	Calorific value, 1000 Btu/lb or Btu/cu ft	Design heat rate, Btu/kWh	Maximum sulfur content, %	Combustion additive	Additive introduction	Sootblower					
						Type	Hp (each)	Manufacturer											Working fluid	Manufacturer				
MAN	2	7900	4696	IR	S	T ₁₂	27 500	DL	2/323	3/423	546	YU	C	11.9	8400 ²⁴	4.3 ²⁵	No	NAv	Air	CV	1			
MAN	2	13 400	3256	IR	HvC	MIS	24 600	DL	2/123	2/323	475	YU	Cr	145 ²⁶	8065	1	Yes	NAv	Air	DP	2			
MAN	2	13 400	3256	IR	HvC	MIS	24 600	DL	2/123	2/323	475	YU	Cr	145 ²⁶	NAv	1	Yes	NAv	Air	NAv	3			
MAN	2	2950	3110	IR	S	T ₁₃	15 700	WE	2	2/523	509	SWE	DSO, RSO, G	8075	35	No	NAv	St	CV	4				
MAN	2	NAv	3530	EJ	S	T ₁₃	17 500	GE	2/123	3/123	479	CHH, YU	C	9.7 12.5	8032	NAv	No	NAv	St	DP	5			
MAN	1	12 550	4570	DL	S	T ₁₃	34 800	DL	2/123	2/423	548	WO	C	12	7462 ²⁷	1.5	No	NAv	St	DP	6			
MAN	2	6260	4985	IR	S	T ₁₃	21 500	GE	2/123	2/523	519	FW	C ²⁸	12.5	8676	3.5	No	NAv	Air	DP	7			
MAN	1	6700	3422	NAv	S	T ₁₃	15 577	NAv	1	3/523	517	NAv	C	17	9100	2.5	No	NAv	Air	DP	8			
MAN	1	11 550	2330	PP	S	T ₁₃	17 025	WE	1	0/223	362	STW	Cr	19.4	10 400	0.1	No	NAv	Air	DP	9			
MAP	2	NAv	NAv	DL	S	T ₁₃	13 000	GE	1	2/423	467	FW, YU	C	8.3	8082	1.2	No	NAv	St	CV	10			
MAP	2	4500	3579	PP	S	T ₁₃	13 500	GE	2	2/423	474	YU	C	10.8	NAv	3	No	NAv	St	DP	11			
MAP	2	5550	1700	DL	S	T ₁₃	8930	GE	1	0/223	318	WE	RSO	18	8950	0.5	MgO	Fub	St	CV	12			
MAP	1	10 300	4520	DL	S	T ₁₃	NAv	WE	NAv	504	SWE	RSO, G	NAv	17	9300	1.7	Yes	Fub	St	DP	13			
MAN	1	9706	4375	DL	S	T ₁₃	21 500	DE	1	2/523	501	SWE	L	6.8	9900 ²⁹	0.6	No	NAv	Air	CV	14			
MAN	2	4700	3135	IR	S	T ₁₃	11 425	GE	1/223	2/423	481	YU	C	8.4	9300	0.6	No	NAv	St	CV	15			
MAN	2	4340	2926	PP	S	T ₁₂	9500	GE	1	2/423	493	YU	C	9.2	9900	0.7	No	NAv	St	CV	16			
MAN	2	4075	4565	DL	S	T ₁₃	11 950	DL	1	2/523	488	WE	C, G	11.4 1035	NAv	3.1	No	NAv	Air	CV	17			
MAN	1	6740	7200	Cr	S	T ₁₃	16 200	GE	1	2/523	487	MLW, CHH, FW	RSO	18.3	9161	NAv	NAv	St	DP	18				
MAN	2	4800	3050	DL	S	T ₁₃	9900	WE	2/123	4/423	481	BLH	C	12	9375	4	No	NAv	St	DP	19			
MAP	1	8034	2743	CIP	S	T ₁₃	16 800	GE	1	2/423	485	FW	C	12.3	NAv	3.5	No	NAv	St	CV	20			
MAN	2	4500	3200	DL	Reg	MIS, T	10 000	GE	1	2/523	470	YU, BLH, CHH	RSO	17.7	7728	2.9	No	NAv	St	CV	21			
MAN	1	6790	7837	PP	S	T ₁₃	17 474	GE	1	3/523	492	CHH, STW	Cr	18	9300	NAv	Yes	Fub	St	CV	22			
MAN	1	9000	3200	DL	S	T ₁₃	15 700	GE	1	2/523	489	YU, BLH, CHH	Cr	17.7	7793	2.9	No	NAv	St	CV	23			
MAN	2	3620	3310	DL	S	T ₁₃	7500	GE	1	2/423	485	YU	C	12.2	NAv	0.5	N	NAv	St	CV	24			
MAN	1	7320	2996	DL	S	T ₁₃	13 838	GE	1	2/423	460	YU	NAv	NAv	9550	NAv	NAv	NAv	St	CV	25			
MAP	1	7600	2950	DL	S	T ₁₃	14 200	WE	1	2/523	478	SWE, CHH	RSO, Cr	19.5	7924	0.5	NAv	Fub	Air	DP	26			
MAP	1	6360	2250	DL	S	T ₁₃	11 000	DL	1	0/223	353	YU	RSO, Cr	19.19.5	8750	0.3	MgO	Fub	St	CV	27			
MAP	1	6290	3100	IR	HvC	MIS	12 000	NAv	1	2/523	NAv	WE	RSO	18.3	9079	NAv	Yes	NAv	Air	CV	28			
MAP	1	7300	3007	NAv	Reg	T ₁₃	14 686	NAv	1	3/523	530	WE	C	10.7	9175 ⁴⁰	2.3	No	NAv	Air	DP	29			
MAP	2	3000	2446	DL	HvC	M	6000	GE	NAv	NAv	NAv	NAv	C	9.7	NAv	1.2	No	NAv	Air	DP	30			
MAN	2	3192	6882	PP	S	T ₁₂	7000	GE	1	1/423	487	STW	C	8.8	8032	1	No	NAv	St	CV	31			
MAN	2	1430	1800	IR	Reg	M	2000	GE	1	0/123	267	WM	DSO, RSO, Cr	Var	8870	0.3	No	NAv	St	CV	32			
MAN	2	2375	3375	AC	Reg	M	5500	AC	1	2/323	482	YU	C	11.5	9337	1.4	No	NAv	St	DP	33			
MAN	2	2850	2300	PP	Reg	M	5000	GE	1	0/223	359	WE, CHH	RSO, G	18.8, 1080	10 000 ⁴¹	0.5 ⁴²	No	NAv	St	DP	34			
AP	1	1095	1430	BPC	Reg	M	1250	WE	1	N/223	250	COC	G	1050	9140	N	N	NAv	N	St	CV	35		
MAP	2	3090	2089	WO	HvC	M	4500	GE	1	2/323	472	YU	G	1000	9940 ²⁰	N	No	NAv	N	St	CV	36		
MAP	2	1570	2899	PP	HvC	M	3500	AC	1	2/523	475	YU	DSO	19.5	9500 ²⁰	0.3	No	NAv	N	St	CV	37		
MAP	2	1750	2400	DL	Reg	M	3000	WE	1	3/223	476	STW, CHH	RSO, Cr	19.19.3	7976	1	MgO	Fub	St	DP	38			
MAP	2	1335	2403	AC	HvC	M	2500	AC	2	3/223	464	STW, LAW	G	1096	8155	0	No	NAv	N	St	DP	39		
MAN	2	3542	3200	DL	S	T ₁₃	7060	DL	2	3/323	467	SWE	L	7	10 890	0.8	No	NAv	St	DP	40			
MAP	1	7590	2950	NAv	S	T ₁₃	14 600	WE	1	2/4	485	NAv	DSO, G	11.4	9474	0.145	No	NAv	St	NAv	CV	41		
MAN	2	NAv	NAv	DL	S	T ₁₃	7000	GE	NAv	NAv/NAv	NAv	NAv	C	11.0	7971	3.5	No	NAv	Air	DP	42			
MAN	2	1800	2300	NAv	HvC	M	3500	NAv	1	2/323	466	NAv	DSO, RSO, G	18.5	9850 ⁴³	NAv	Yes	Fub	St	DP	43			
MAN	2	1300	5195	IR	Reg	M	2250	NAv	1	N/2	220	NAv	RSO	18.5	NAv	1	NAv	St	DP	44				
MAN	2	1530	2500	BJ	Reg	M	3000	GE	1	2/2	380	SWE	C, G	10.3, 1000	9500	1	No	NAv	St	DP	45			
MAN	2	890	1500	PP	HvC	M	1250	WE	1	2/2	443	YU	G	1000	NAv	N	No	NAv	N	St	DP	46		
MAN	2	800	2100	AC	Reg	M	1250	AC	1	2/1	468	SWE	G	1075	9205	N	No	NAv	St	APC	47			
MAN	2	NAv	NAv	NAv	M	NAv	NAv	NAv	1	2/2	439	NAv	DSO, G	10,800	10 800	0.8	Yes	Fs	St	DP	48			

only
 turbine shaft
 available
 burner
 ion exchange
 sized
 pump or blower
 osmosis
 circulating pump
 oil
 control
 filters
 steel
 tangential burners
 control
 ray
 rest of footnotes
 cycle plant; 20 MW is generated
 turbine that will burn DSO at

startup and washed RSO during normal operation. For data on the combustion turbine, see page S-12
 51 - Standby unit
 52 - One motor rated 1250 hp, one 900 hp
 53 - DSO, 18,984 Btu/lb; G, 1068 Btu/cu ft
 54 - Primary steam source, main-turbine bleed; secondary steam source, main steam and auxiliary boiler
 55 - Coal is transported via five unit trains, comprised of 600 cars and 22 locomotives
 56 - Total output from two boilers supplying steam to one turbine/generator
 Other bit data pertain to individual units
 57 - At 86.6% efficiency
 58 - Data are for each of two 50%-capacity feedpumps. Primary steam source, intermediate-turbine exhaust; secondary steam source, main steam or auxiliary boiler. A motor-driven feedpump is provided for startup service
 59 - Sun-bituminous coal
 60 - One rated 219,500 cfm; one, 162,500
 61 - One rated 345,000 cfm; one, 262,000
 62 - Sewage effluent is treated for bit makeup
 63 - Combined-cycle plant; 135 MW is generated by two gas turbines. For data on combustion turbines, see page S-12
 64 - Based on oil firing

65 - Data are for each of four boilers
 66 - Data are for each of two boilers
 67 - Data are for the main feedpump. Standby pump, manufactured by DL, is rated 3660 gpm at 3001 psig. It is driven by an 8000-hp motor manufactured by GE
 68 - Primary steam source, cold reheat; secondary steam source, main steam
 69 - First reheat, 1025 F; second reheat, 1050 F
 70 - First reheaters 124,000 sq ft; second reheater, 167,000 sq ft
 71 - All tandem-compound, indoor units unless otherwise specified
 72 - Data are for the main feedpumps. A 2800-gpm motor-driven pump is available for startup service
 73 - Data are for the main feedpump. A startup pump, rated at 40% of full capacity, also is installed
 74 - Compartmented nozzle
 75 - pH control; phosphate injection
 76 - Primary steam source, main steam; secondary steam source, auxiliary blr
 77 - Data are for the main feedpumps. Standby pump, manufactured by BJ, is rated 3060 gpm at 4573 psig. It is driven by a 12,146-hp motor
 78 - Steam source: cold reheat only

79 - One motor rated 6000 hp, one 1250 hp
 80 - Data are for the main feedpump. Standby pump, manufactured by DL, is rated 4500 gpm. It is driven by a 10,000-hp motor
 81 - Data are for the main feedpump. Startup pump, manufactured by DL, is rated 3180 gpm at 2620 psig. It is driven by a 5550-hp motor manufactured by AC
 82 - Steam-coil air heater
 83 - Primary steam source, main-turbine bleed; secondary steam source, auxiliary boiler
 84 - Data are for the main feedpump. Startup pump, manufactured by IR, is rated 1790 gpm at 2000 psig. Regulator controls flow; separate 2000-hp turbine is the prime mover
 85 - In fuel line
 86 - Data are for the main feedpump. Startup pump is rated 3550 gpm at 2748 psig. It is driven by a 6000-hp motor
 87 - Flash evaporation



Gas Turbines

Company	No. of units	Total power, MW	Mfr	Startup
Pub Service of Oklahoma	1	240	WE	73
Pub Service Elec & Gas Co	1	140	TP	73
Jersey Central Pwr & Light	1	325	GE	74
Ohio Edison Co	1	240	GE	74
Duquesne Light Co	1	270	GE	74
Houston Lighting & Pwr	2	600	GE	74
Louisiana Pwr & Light Co	1	200	GE	74
Pennsylvania Electric Co	1	250	...	74
El Paso Electric Co	1	240	WE	75
So California Edison Co	2	520	WE	75
Central Vermont Pub Service Co	1	275	WE	77

Gas-turbine sales still climbing

Recent surge in combined-cycle orders indicates these units will prove stiff competition for peaking/cycling boilers

By Robert G Schwieger, Associate Editor

The gas-turbine market is stronger than ever and appears to be growing, despite predictions of a few reputable sources that sales would taper off by 1972 and average approximately 2500-3500 MW/yr until about 1980. In fact, about 600 MW of gas-turbine generating sets were sold in the first half of 1972 alone (p S.12-S.15).

Several years ago, some experts picked the early 1970s as the time for gas-turbine sales to peak. They felt that orders were being placed by utilities solely to fill the generation gap created when nuclear central-station licensing and environmental problems delayed the startup of these plants. However, it now appears many utilities recognize that gas turbines should not be considered merely as a stop-gap measure, but rather as an important part of their system's generation mix. Evidence: orders received by a few manufacturers for open-cycle units with startup dates in 1975 and beyond, and the popularity of preengineered combined-cycle plants (table, above).

At least one manufacturer predicts orders will continue at the current rate of about 6000-7000 MW/yr for another year or two. This period should be followed by a slight dip in sales, assuming large nuclear units come on-line in significant numbers. But then, after utilities have had sufficient time to reassess their generation mix and future requirements, orders are expected to increase and probably exceed levels attained in the early 1970s.

Combined-cycle orders have come on strong after about a six-month lull that

followed the first orders announced last year (**POWER**, October 1971, pp 105-109). Manufacturers are encouraged that these plants will play a major role in midrange generation. Even utilities that do not have gas turbines in their systems are showing considerable interest. Remember that combined cycles were difficult to promote in the early days because the preengineered concept was relatively new, and because some utilities were dissatisfied with the reliability of gas turbines in peaking service.

Several reasons exist for the surge in utility interest:

□ High availability of gas turbines can be achieved when these units are operated at relatively constant load for extended periods and when they are maintained in accordance with manufacturers' instructions. Example: the outstanding performance of equipment in pipeline service.

□ Some old fossil-fired central stations are not operating as well as expected in cycling service.

□ In some cases, it is more economical to order a combined-cycle plant than to invest capital in pollution-control equipment for an older station that might not withstand the rigors of cycling operation.

□ There is little operating data to support vendor claims of high reliability for boilers and turbines designed specifically for peaking/cycling service.

□ Environmental impact of combined-cycle systems should be less than that of peaking/cycling units because of reduced cooling-water requirements and the utilization of higher quality fuels.

□ Construction costs of combined-cycle plants are relatively low because most components are assembled at the factory and shipped in modules to the plant site.

Reducing NO_x from gas turbines

Perhaps one of the biggest problems facing vendors of preengineered combined-cycle systems is the reduction of nitrogen oxides (NO_x) from gas turbines. Although the most stringent NO_x laws in force today can be met by injecting demineralized water into the combustion chamber, this method is expensive. Most gas-turbine manufacturers feel they will be able to offer a combustor that will minimize NO_x without water injection shortly after Environmental Protection Agency determines an acceptable procedure for calculating emissions (**POWER**, Sept 1972, p 84).

Regarding the survey pages, note that no orders were received by the following companies during the survey period, June 1, 1971 to May 31, 1972: Tokyo Shibaura Electric Co. Ltd.-Toshiba (Japan); Siemens AG (Germany); Franco Tosi, SpA (Italy); Société Anonyme Cockerill-Ougree-Providence (Belgium) and Ateliers de Constructions Electriques de Charleroi (Belgium).

Free-world manufacturers of gas turbines for utility and industrial service (larger than 1000 hp) that did not respond to the **POWER** survey: Auto Diesels Braby Ltd (Great Britain); Dresser Industries, Inc (U.S.); Gutehoffnungshütte Sterkrade AG (West Germany) and NV Motorenfabriek Thomassen (Netherlands).

PROJECT

COMPANY

EQUIPMENT
LOCATION

Manufacturer

Model

Units ordered
6/1/71-5/31/72

Primary application

Black plant installation?

Method of remote
operation

Normal power, MW

Normal power, 1000 hp

Standard elevation, ft

Ambient temp, F

Maximum power, MW

Maximum power,
1000 hpAmbient temp for max.
power at std elevation, F

Normal startup

Fast startup

Emergency
startup

RATING AND CONDITIONS

														Minutes to reach normal power			
														Normal	Fast	Emergency	
1	Georgia Power Co.	GA	WE	W-501	625	PP	No	Dw, Spv	64.4	0	59	69	59	30	20	10	
2	Northern States Power Co.	Blue Lake, MN	TD	Mega-Pak J1	4	PP	No	Dw	48.4	1000	80			20	13		
3	Jersey Central Power & Light Co.	Holland Twp, NJ	GE	MS 7001	427	BI	No	Dw	44.2	300	80			30		12	
4	Wisconsin Public Service Corp.	West Marinette, WI	TP	Twin Pac 19	125	PP	Yes	Dw, Spv						8	3		
5	City of Cape Town	Cape Town, South Africa	CW	Mod Pod-40	126	PP	Yes	Dw	40	1000	30			3	2		
6	Florida Power & Light Co.	Ft. Lauderdale, FL	TD	ER-224	1249	PP	Yes	Dw	38.0	1000	80	42.7	80	5	3	3	1700
7	Vineyard Electric Utility	Vineyard, NJ	WE	W-251	148	PP	Yes	Dw, Spv	31.1		59	33.6	59	20	10	5	
8	Consolidated Edison Co of NY, Inc.	New York, NY	GE	MS 5001	1645	PP	Yes	Spv	20.1	0	35	21.8	35	10		5	1800
9	U.S. Navy Propulsion Test Center	Trenton, NJ	TP	FT4A-11LF	1	MO	No	Dw		27.4	0	90	30.6	90			1200
10	Freeport Electric Dept.	Freeport, NY	CW	Mod Pod-20		PP	Yes	Dw	20	1000	80			3	2		
11	U.S. Air Force	GU1	TP	Power Pac 17	118	PP	Yes	Dw, Spv		12		12	12	8	3		
12	Golden Valley Electric Assn, Inc.	Fairbanks, AK	GE	MS-5001	146	PP	No	Dw	17.5	1000	30			8			
13	Arabian American Oil Co.	Uthmaniyah, Saudi Arabia	GE	MS-5002	244	MO	No	Dw		20.3	0	120		10			
14	Volterre Electric Corp, Inc.	Hersey, MI	CBC	Coberra 12543	2	PP	Yes		11.0	1000	80	12.5	80	8	6	3.5	1070
15	Franklin Municipal Plant	Franklin, LA	TD	EA-113	1	PP	Yes	N	10.2	0	95			7	3	3	1000
16	Michigan Wisconsin Pipe Line Co.	Gulf of Mexico	GE	MS-3002	242	Gh	No	Spv		13.1	1000	80		10			
17	Union Oil Co of Canada Ltd.	Lobo, Ont., Canada	CSC	Coberra 125	541	Gh	No	Dw		12.5	1000	30					800
18	Kloeckner Humboldt-Deutz AG	West Germany	AV	TF 35	4	PP	Yes	N-33	3.5	0	80	4.2	80	1	1	1	1700
19	Oasis Pipeline Co.	TX1	IR	GT-40	1932	Gh	Yes	Spv		4	0	59	5.5	80	4	4	1260
20	Tennessee Gas Pipeline Co.	Paris, IL	ALN	501-K1311	211	Gh	Yes	Dw		3.6	0	60		1			1700
21	Amoseas Inc.	Libya	SD	CS3000	834	Gh	Yes			3.5	0	59		1			
22	Amoco International, Ltd.	Gulf of Suez	SD	MD3000	836	MD	Yes	Dw		3.5	0	59		1			1450
23	Alberta Government Telephone Commn	Calgary, Alta., Canada	SD	GSE3000	237	SP	Yes	Dw		2.5	0			1			1450
24	Abu Dhabi Petroleum Co, Ltd.	Persian Gulf	SD	GSC3000	3	BI	Yes			2.4	0	59		1			
25	Petroleos Mexicanos	Mexico	CBC	Coberra 30	5	Gh	No	Spv		3	1000	80	4	30			1000
26	National Iranian Oil Co.	Iran	AV	TF 25	3	Pd	Yes	N		2	0	80	2.8	80	1	1	1400
27	Combined Constructors Co.	White Plains, NY	NAT	Viking-SBG	540	PP	Yes	N		1.2	0	59		1			1420
28	Chicago Metropolitan Sewage District	Chicago, IL	NAT	Viking-CO	1	TE	No	N		1.75	0	59		1			1420
29	IAPCD2	Indonesia	NAT	Viking-COG/T	8	TE	Yes	Dw		1.0	0	59		1			1420
30	Abu Dhabi Petroleum Co Ltd.	Persian Gulf	NAT	Viking-COG	3	BI	No	Dw		1	0	59		1			1420
31	Dowell Div. Dow Chemical Co.	Mobile, AL	SO	IPP1000	10	MD		Dw		1.2				1			1450
32	Chevron Oil Co.	Ft. Saskatchewan, Alta., Can.	SO	MD1000	550	MD		Dw		1.2	0	59		1			1450
33	Amoseas Inc.	Libya	SD	CS1200	1053	Gh	Yes			1.2	0	59		1			1450
34	City of Andover	Andover, MA	SO	GSE1000	132	SP	Yes	Dw		0.9	0	59		1			1450
35	Pacific Telephone & Telegraph Co.		SO	KS1000	894	SP	Yes			0.8	0	59		1			1450
36	Amoco Canada Petroleum Co.	Ft. St. John, Alta., Canada	SO	GSC1000	255	TE	Yes	Dw		0.8	0	59		1			1450

MANUFACTURERS

AKT	AEG-Kanz Turbinenfabrik GmbH
ALN	Detroit Diesel Allison Div., General Motors Corp.
ALS	Societe Generale de Constructions Electriques et Mecaniques (ALSTHOM)
AV	Lycorning Div., Avco Corp.
BBS	Brown Boveri Sulzer Turbomachinery Ltd
CBC	Cooper-Bessmer Co.
CW	Curtiss-Wright Corp.
FIA	Fiat SpA, Divisione Mare
GEG	GEC Gas Turbines Ltd
GE	General Electric Co.
HIT	Hitachi, Ltd.
HS	Hispano-Suiza, Division de la SNECMA
IR	Ingersoll-Rand Co.
JBE	John Brown Engineering Ltd
KWU	Kraftwerk Union AG
KV	A/S Kongsberg Vapenfabrikk
MHI	Mitsubishi Heavy Industries, Ltd.
NAT	North American Turbine Corp.
NP	Nuovo Pignone SpA
ORE	Orenda Ltd.
PW	Pratt and Whitney Aircraft Div., United Aircraft Corp.
RR	Rolls-Royce Ltd.
RUS	Ruston Gas Turbines Ltd.
SO	Solar Div. of International Harvester Co.
STA	Stal-Laval Turbin AB
TD	Turbodyne Corp.
TP	Turbo Power and Marine Systems, Inc.
WE	Westinghouse Electric Corp.
WKR	Werkspoor-Amsterdam NV

SYMBOLS

Ac	Annular combustor
Acc	Accelerometer

Bc	Bearing cap
BI	Base load
BpT	Blade-path temperature
CaC	Canannular combustor
Cdp	Compressor discharge pressure
Cmb	Combination, combined cycle
CrO	Crude oil
Cv	Compressor bleed valves
DF	Dual fuel
DsO	Distillate oil
Dw	Direct wire
E	Electronic
Ec	Engine case
EH	Electrohydraulic
EM	Electromagnetic
EP	Electropneumatic
G	Natural gas
Gh	Gas handling
HoC	Horizontal combustor
Hy	Hydraulic
ISi	Inlet silencer
Itg	Integrated
K	Kerosene jet A
MD	Mechanical drive
N	None
NAP	Not applicable
OPC	Open cycle
Pd	Pump drive
PP	Peaking power and standby
ReC	Recovery cycle with exhaust to boiler
Rag	Regenerative cycle
Rel	Relative motion between bearing cap and shaft
RdO	Residual oil
Ry	Relay
Sep	Separate
Sk	Stack (manifold)
Sol	Solid state

SP	Standby power only
SpT	Speed/time
Spv	Supervisory (telemetry)
Ta	Turbine exhaust (blade path)
TE	Total energy
Ti	Turbine inlet
Ts	True shaft
Tws	Twin spool
VeC	Vertical combustor
Vig	Variable inlet guide vanes

FOOTNOTES

- Various locations
- Independent Indonesian American Petroleum Co
- Exact location not available
- Manufactured in Mannheim, West Germany
- Iranian Electric Power Generation & Transmission Co
- Undisclosed
- Ratio of absolute compressor-discharge pressure to absolute compressor-inlet pressure
- In some gas-turbine packages, turbine driving the external load — compressor, pump or generator example — is mounted on a shaft separate from the gas-generator's compressor and turbine shaft; this machine is called the free (or power) turbine. Packages without a free turbine develop power external load and gas-generator compressor with the turbine described under the "Gas generator" also exhaust silencer and soundproof building
- Also exhaust silencer
- ALN offers five versions of its 501 engine: 501-K5, 501-K13 and 501-K16A burn natural gas; 501-K16A burn liquid fuel. K5 and K14, similar in performance, have base-load ratings of 3140 the following conditions: ambient temperature, 60 F; elevation, sea level; turbine-inlet temperature, 13,820 rpm. K13 and K15, also similar in performance (detail in tabulation), have first-stage blades and vanes to permit higher gas temperatures at turbine inlet. Hence, power is about 15% over the K5 and K14 models. K16A performance is comparable to the K13 except it which offers additional speed flexibility. Other units sold during 6/1/71-5/31/72 survey period: Potomac Telephone Co, Baltimore, MD (2 units, K14), generator drives; Trunkline Gas Co, Corp (1, K13) and Longville, LA (1, K13), compressor drives; Pacific Telephone & Telegraph Co, Corp (2, K15), San Francisco, CA (1, K15) and Oakland, CA (1, K15), generator drives; New York T. Co, New York, NY (2, K15), generator drives; Warren Petroleum Co, Cameron, LA (1, K13), comp Northern Natural Gas Co, Hugo, MN (1, K13), compressor drive; Kansas Nebraska Natural Gas Lakin, KS (1, K13) and Scott City, KS (1, K13), generator drives; Coastal States Gas Products

GAS GENERATOR					FREE TURBINE			COM BUSTORS		FUEL		INSTRUMENTATION AND CONTROL											PROJECT		
Manufacturer	Number of shafts per generator	Number of compressor stages	Number of turbine stages	Turbine speed, rpm	Number of shafts	Number of rotors	Number of Stages per rotor	Number	Type	Type	Switch fuel auto matically under load?	Type of soundproofing	Speed of driven equipment, rpm	Type of control system hydraulic	Method of measuring turbine speed	Location of cycle temperature monitor	Seipoint power control?	Method of controlling turbine surge	Method of controlling turbine acceleration	Method of measuring turbine vibration	Exhaust temperature control?	Turbine and generator controls			
WE	1	17	4	3600	N	N	N	16	Ac	23	Yes	ISI ⁹	3600	Sol/EP	24	BpT,Sk	Yes	Cv	SpT	Bc	Yes	Itg	1		
TO	1	17	5	3600	N	N	N	1	VeC	DsO	Yes	ISI ⁹	3600	Sol/EP	24	Te	Yes	Cv	SpT	Rel	Yes	Itg	2		
GE	1	17	3	3600	N	N	N	10	CaC	DsO, CrO	Yes	ISI ¹⁰	3600	Sol/EP	29	Te	Yes	Vig	BpT ³⁰	Rel	Yes	Itg	3		
TP	2	7/13	1/21 ¹³	22	1	1	2	8	CaC	G,DsO	Yes	ISI ⁹	3600	Ry/	16	EM	Te	Yes	Cv	SpT	Ec	Yes	Itg	4	
RR	2	7/51 ¹³	1/11 ¹³		1	1	2	8	Ac	DsO	Yes	ISI ⁹	3000	Ry/EH	E	EM	Te	Yes	Cv	SpT	No	Itg	5		
PW	2	7/81 ¹³	1/21 ¹³	8800/6500 ¹³	1	1	2	8	CaC	DF	Yes	ISI ⁹	3600	Ry/E	35	Ti,Te	Yes	TWS	SpT	Bc	Yes	Itg	6		
WE	1	16	3	4894	N	N	N	8	Ac	23	Yes	ISI ⁹	3600	Sol/EP	24	Te/Sk	Yes	Cv	SpT	Rel	Yes	Itg	7		
GE	1	17	2	5100	N	N	N	10	CaC	DsO	No	ISI ¹⁰	3600	Sol/EP	35	Sk	Yes	N	SpT	Bc	Yes	Itg	8		
TP	2	7/81 ¹³	1/21 ¹³	8600/6350 ¹³	1	1	2	8	CaC	K	No	ISI ⁹	3600	Ry/EH	EM	Te	N	Cv	SpT	Ec	Yes	NAP	9		
RR	2	7/51 ¹³	1/11 ¹³		1	1	2	8	Ac	DsO	Yes	ISI ⁹	3600	Ry/EH	E	EM	Te	Yes	Cv	SpT	No	Itg	10		
TP	2	7/13	1/21 ¹³	15	1	1	2	8	CaC	G,DsO,K	Yes	ISI ⁹	3600	Ry/	16	EM	EM	Sk	Yes	Cv	SpT	Ec	Yes	Itg	11
GE	1	16	2	5100	N	N	N	10	CaC	G	No	ISI ⁹	3600	Sol/EP	EM	Sk	Yes	N	SpT	Bc	Yes	Itg	12		
GE	1	15	1	5100	1	1	1	12	CaC	DF	Yes	ISI ⁹	4670	Sol/EP	EM	Sk	Yes	N	SpT	Bc	Yes	NAP	13		
RR	1	17	2	7650	1	1	1	6	CaC	DF	No	ISI ⁹	3600	Ry/Sol/E	E	EM	Te	Yes	Cv,Vig	SpT	Rel	No	Itg	14	
PW	2	7/81 ¹³	1/21 ¹³	8600/6350 ¹³	1	1	1	8	CaC	DsO	No	ISI ⁹	3600	Ry/E	35	Ti,Te	Yes	TWS	SpT	Bc	Yes	Itg	15		
GE	1	15	1	6900	1	1	1	6	CaC	G	No	ISI ⁹	6500	Sol/EP	EM	Sk	Yes	N	SpT	Bc	Yes	NAP	16		
RR	1	17	3	7500	1	1	2	8	CaC	G	No	ISI ⁹	5000	Ry/E	E	EM	Te	Yes	Cv,Vig	SpT	Rel	No	NAP	17	
AV	1	8	2	18,000	1	1	2	1	Ac	DsO	No	ISI ⁹	1500	Ry/Sol/E	E	EM	Te	Yes	Cv	SpT	Rel	Yes	Itg	18	
ALN	1	14	2	13,800	1	1	2	6	CaC	DF	Yes	ISI ¹⁰	13,800	Sol/EP	EM	EM	Te	Yes	Cv	SpT	Rel	Yes	NAP	19	
ALN	1	14	4	13,820	N	N	N	6	CaC	G	No	ISI ¹⁰	1200	Ry/E	EM	EM	Te	Yes	Cv	BpT	Acc	No	NAP	20	
SO	1	11	2	14,300	1	1	1	1	Ac	G	No	ISI ¹⁰	14,300	Ry/Sol/	35	Ti,Sk	Yes	Vig	EM	TS	Yes	NAP	21		
SO	1	11	2	14,300	1	1	1	1	Ac	G	No	ISI ¹⁰	6000	Ry/Sol/	35	Ti,Sk	Yes	Vig	EM	TS	Yes	NAP	22		
SO	1	11	3	14,300	N	N	N	1	Ac	DsO	No	ISI ¹⁰	EM	Ry/Sol/	35	Ti,Sk	Yes	Cv	EM	TS	Yes	Itg	23		
SO	1	11	3	14,300	N	N	N	1	Ac	G	No	ISI ¹⁰	EM	Ry/Sol/	35	Ti,Sk	Yes	Vig	EM	TS	Yes	Itg	24		
CBC	1	14	2	11,650	1	1	1	1	Ac	G	No	ISI ⁹	9000	Ry/E	E	EM	Te	Yes	Cv	SpT	Rel	Yes	NAP	25	
AV	1	8	1	18,000	1	1	2	1	Ac	DF	No	ISI ¹⁰	3850	Sol/	E	EM	EM	Yes	Cv	SpT	EM	Yes	NAP	26	
KV	1	1	1	17,100	N	N	N	1	Ac	DsO	No	ISI ⁹	1800	Ry/EH	EM	EM	Te	No	N	39	Bc	No	Itg	27	
KV	1	1	1	17,100	N	N	N	1	Ac	DF	No	ISI ³⁶	3600	Ry/EH	EM	EM	Te	No	N	39	Bc	No	Itg	28	
KV	1	1	1	17,100	N	N	N	1	Ac	DsO	No	ISI ³⁶	1800	Ry/EH	EM	EM	Te	No	N	39	Bc	No	Itg	29	
KV	1	1	1	17,100				1	Ac	PrG	No	ISI ⁹	1800	Ry/EH	EM	EM	Te	No	N	39	Bc	No	Itg	30	
SO	1	8	2	22,300	1	1	1	1	Ac	DsO	No	ISI ¹⁰	3600	Ry/Sol/	35	Sk	No	Cv	EM	TS	No	Itg	31		
SO	1	8	2	22,300	1	1	1	1	Ac	G	No	ISI ¹⁰	22,300	Ry/Sol/	35	Sk	No	Cv	EM	TS	No	NAP	32		
SO	1	8	2	22,300	1	1	1	1	Ac	G	No	ISI ¹⁰	22,300	Ry/Sol/	35	Sk	Yes	Cv	EM	TS	No	NAP	33		
SO	1	8	3	22,300	N	N	N	1	Ac	DsO	No	ISI ¹⁰	1800	Ry/E	35	Sk	No	Cv	SpT	EM	Yes	Itg	34		
SO	1	8	3	22,300	N	N	N	1	Ac	DsO	No	ISI ⁹	1200	Ry/E	35	Sk	No	Cv	SpT	EM	Yes	Itg	35		
SO	1	8	3	22,300	N	N	N	1	Ac	G	No	ISI ¹⁰	EM	Ry/Sol/	35	Sk	EM	Cv	EM	TS	Yes	Itg	36		

(K13), compressor drive: Natural Gas Pipeline Co of America, Johnson's Bayou, LA (1), K13), compressor drive: undisclosed company in Lake Arthur, LA (1), K13), compressor drive: State University of NY at Stony Brook, NY (2), generator drives: Cities Service Gas Co, Santa, KS (16A) compressor drive: Oasis Pipeline Co, various locations in Texas (18, K16A), compressor drives. The Pac series comprises several models. Depending on the ambient conditions, elevation, etc., normal-power will fall between 18.7 and 39.35 MW, and peak-power between 21.7 and 42.95 MW; gas temperature at turbine inlet will be between 1135 and 1250 F; pressure ratio, between 11.1 and 14.7. Depending on model, low-pressure compressor has either 10 or 12 stages. Depending on the model, speed of h-o compressor drive will be between 8560 and 8750 rpm; speed of l-p compressor between 6350 and 6690 rpm. Depending on model, analog controls can be electrohydraulic, pneumatic or electronic. Model FT4A-11LF was purchased by US Air Force for use in Vietnam. Power Pacs purchased during survey period for electric generation: New England Gas & Electric Assoc, Cambridge, MA (1 unit, model FT4A-9LF); Elbasco International Corp., Equador (1), FT4A-11LF); British Columbia Hydro Power Auth, Prince Rupert, B.C., Canada (2, FT4C-10F); and TP4-2A-9DF was purchased by Wisconsin Public Service for electric generation in West Marinette, WI. Twin Pacs purchased during survey period for electric generation: Union Electric Co, undisclosed location in Missouri (1 unit, model TP4-2A-11LF); Florida Power Corp., undisclosed location (4, TP4-2C-1LF); Public Service Electric and Gas Co, undisclosed locations in New Jersey (8, TP4-2C-1LF); Portland General Electric Co, undisclosed locations in Oregon (2, TP4-2C-1LF); Nebraska Public Power Dist, Hebron, Neb., and Shelton, NE (3, TP4-2C-1LF); Long Island Lighting Co, Glenwood Landing, NY (5, TP4-2C-1LF);

Southern California Edison Co, undisclosed location (1, TP4-2C-10F); Wisconsin Public Service Corp, undisclosed location (1, TP4-2C-10F); Wisconsin Power & Light Co, undisclosed location (2, TP4-2C-10F). 21 - Twin Pac series comprises several models. Depending on the model, ambient conditions, elevation, etc., normal-power rating will fall between 36.85 and 63.6 MW, and peak-power rating between 39.8 and 65.6 MW; gas temperature at power-turbine inlet will be between 1130 and 1250 F; pressure ratio, between 11.9 and 16.1. 22 - Depending on model, speed of the high-pressure compressor drive will be between 8380 and 8840 rpm; low-pressure drive, between 6280 and 6700. 23 - Distillate, residual and crude oils, plus natural and process gases separately or in combination. 24 - Impulse generator. 25 - Variations of this machine ordered as generator drives by Northern States Power Co, various locations in Minnesota (16 units) and Public Service Co of Oklahoma, Oklahoma City, OK (2) - in a PAC 260 combined-cycle system. 26 - Variations of this machine ordered as generator drives by British Columbia Hydro & Power Authority, Port Hardy, B.C., Canada (1 unit) and Public Service Electric & Gas Co, Bergen, NJ (1). 27 - Variations of this machine ordered as generator drives by Salt River Project Agricultural Improvement & Power Dist (2 units); Northern States Power Co (4); Omaha Public Power Dist (2); Potomac Electric Power Co (4); Louisiana Power & Light Co (2); Duquesne Light Co (3); Philadelphia Electric Co (3); Ohio Edison Co (2); McPherson Bd of Public Utilities, McPherson, KS (2). 28 - Approximate figure. 29 - Inductor alternator frequency measurement. 30 - Also speed/time ratio. 31 - GT-55. 32 - Variations of this machine ordered as compressor drives by Coastal States Gas Producing Co, Freer, TX (1 unit); Alberta Gas Trunk Lines Co, Valleyview, Alta., Canada (1); Phillips Petroleum International Investment Co, Bacton, England (3);

Tennessee Gas Pipeline Co, Warren, PA (1); and undisclosed company in Rumana (5). Variations ordered as pump drives by National Iranian Oil Co for various undisclosed locations in Iran (8 units). 33 - Mobile trailer installation. 34 - Variations of this machine ordered as compressor drives by Colorado Interstate Corp, Mocane, OK (2 units); El Paso Natural Gas Co, Ignacio, NM (1); Humble Oil & Refining Co, locations in Texas (4); Imperial Oil, Ltd., locations in Alta., Canada (5); Mountain Fuel Supply Co, Lark, UT (1); Natural Gas Pipeline Co of America, locations in Texas (4); Oasis Pipeline Co, locations in Texas (4); Shell Oil Co, Gulf of Mexico (1); Union Oil Co of California, Cook Inlet, AK (2). 35 - Magnetic speed pickup. 36 - Variations of this machine ordered by Home Oil Co Ltd, Swan Hills, Alta., Canada (2 units), waterflood-pump drive: Mobil Oil Corp, Cayanosa Station, TX (2), refrigeration-compressor drive: Oasis Oil Co of Libya, Inc, various locations in Libya (8), crude-oil-pump drive: Shell Oil Co, undisclosed locations in Louisiana (1), waterflood-pump drive: Shell Canada Ltd, various locations in Alta., Canada (2), waterflood-pump drive. 37 - Variations of this machine ordered as generator drives by Mountain States Telephone & Telegraph Co, Tucson, AZ (1 unit) and New York Telephone Co, Nassau County, NY (2). 38 - Also soundproof building. 39 - Compare maximum fuel flow to compressor discharge pressure. 40 - Variation of this machine ordered as generator drives by Santa Clara County, San Jose, CA (2 units). 41 - Variation of this machine ordered as a compressor drive by The Gas Council, Chelmsford, England (4 units). 42 - Variations of this machine ordered as compressor drives by Chattanooga Gas Co, Chattanooga, TN (1 unit) and El Paso Natural Gas Co, undisclosed locations (3). Variations of this machine ordered as pump drives by Tennessee Gas Pipeline Co, Ysloskey, LA (1 unit) and Sea Robin Pipeline Co, Gulf of Mexico (3).