Pacemakers/LaSALLE

Reclaim heat, steam to save energy

At this Illinois nuclear power plant, energy from exhaust air streams preheats ventilation air, and reactor steam is tapped to power auxiliaries. Backup systems assure that all operating conditions are met

The LaSalle County station (LSCS) of Commonwealth Edison Co consists of two 1100-MW units located six miles southeast of Marseilles, Ill, on the Illinois River. Each unit is powered by a boiling-water reactor enclosed in a Mark II type containment (over/under configuration), which is steel-lined and made of reinforced concrete.

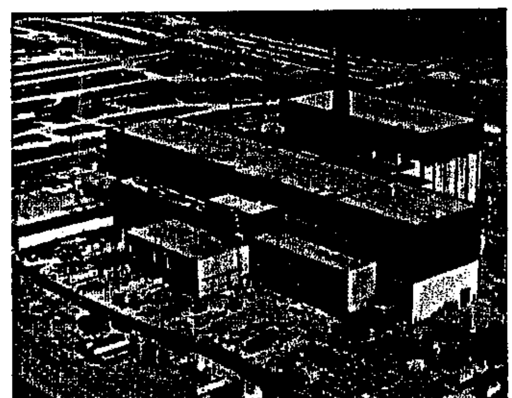
The turbine-cycle heat sink is a 2058-acre cooling lake having an average depth of 13 ft. Makeup water for the lake is pumped five miles to the plant from the Illinois River. The ultimate heat sink is a 75-acre emergency-core-cooling-system pond excavated within the cooling lake.

A unique feature at LSCS is its station heating and auxiliary steam systems (also see Table 1). Large quantities of heat are required (1) to preheat the ventilation air, and (2) to generate steam for processing radwaste, servicing gland seals, inerting moisture-separator/reheaters, etc. Historically, oil- or gas-fired boilers have been used to supply this auxiliary steam. At LSCS, ventilation air is preheated by an air-to-glycol-to-air heat-recovery system, with backup electric blast coils. Electric unit heaters supply perimeter areas of the plant.

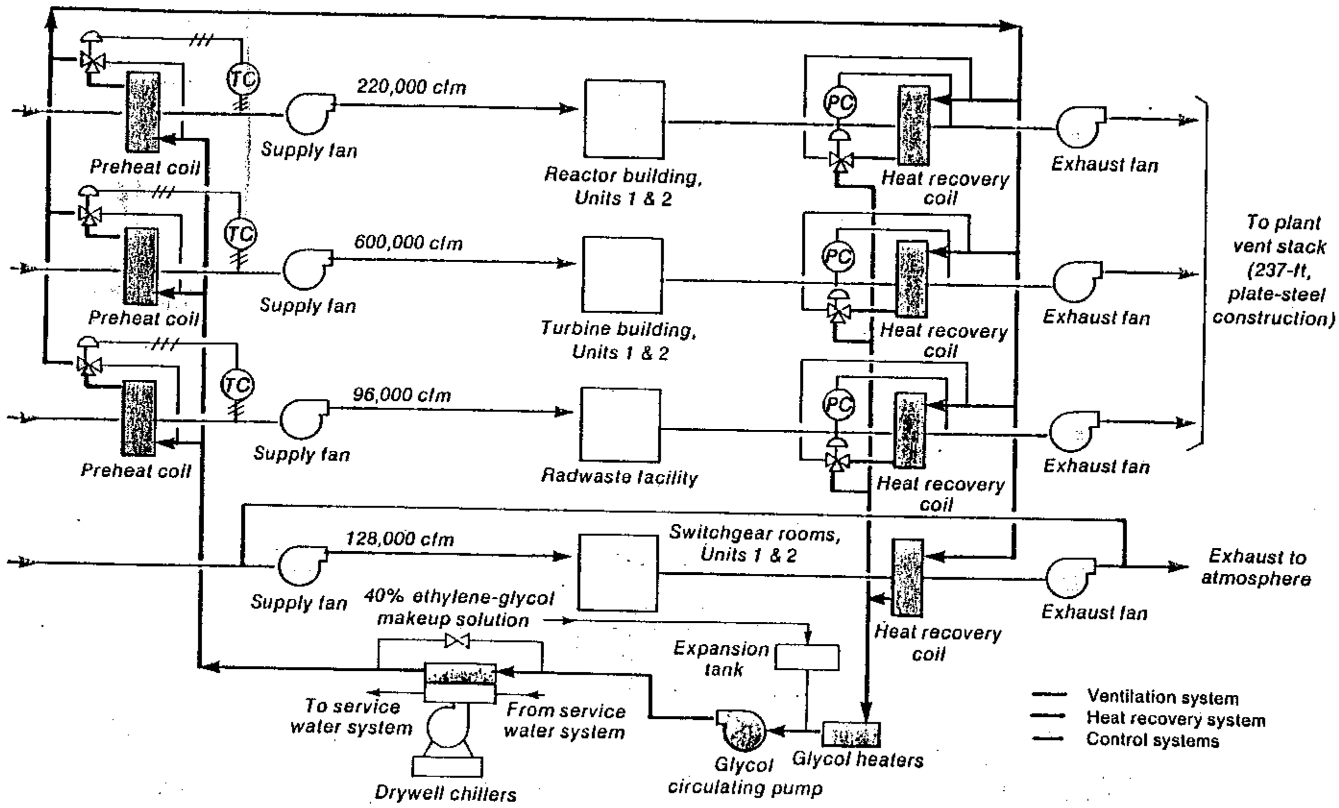
Nuclear steam reboilers with backup electrode boilers were selected to generate process steam. This makes LSCS an all-electric station which will yield a projected saving of roughly 68,000 bbl of oil annually.

Heat-recovery system

A study was conducted in 1971 by



Commonwealth Edison Co's LaSalle County station consists of two 1100-MW boiling-water reactors. Plant, located on the Illinois River, is six miles from Marseilles



1. Heat-recovery system consists primarily of coils in exhaust airstream to reclaim ventilation heat

Sargent & Lundy, the architect/engineer on the project, to determine the best design for station heating and auxiliary steam generation at LSCS. Three designs considered by the engineering firm:

Design A. Heat-recovery system with backup electric blast coils, electric unit heaters for perimeter heating, and nuclear-steam reboilers with backup electrode boilers to provide process steam.

Design B. Electric heating, with electric blast coils for preheating ventilation air, electric unit heaters for perimeter heating, and electrode boilers to provide process steam.

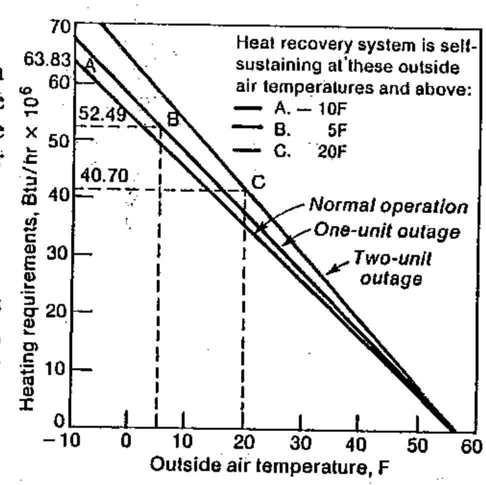
Design C. Oil-fired steam boilers for station heating and process steam—a conventional scheme used at most of Commonwealth Edison's existing nuclear power stations.

The results of this study showed a present-worth saving of about $1-million for Design A over the closest alternative. Since then, of course, ceiling prices for new domestic oil have increased dramatically and imported-oil costs have quadrupled. An updated study shows a total present-worth saving of $20-million for Design A when compared with Design C, which was the second choice. Compared with Design C, a saving of 132%/yr in revenue requirements is reflected and the investment is paid up in one year (see Table 2).

Sources of heat recovery

Heat dissipated from such sources as pump casings, pump motors, fans, generators, switchgear, transformers, pipes, pipe fittings, pipe supports, heat exchangers, and restraints is normally discharged to the outdoor environment via ventilation exhaust air and various cooling-water systems connected with the ultimate heat sink in the cooling lake. These are desirable heat sources.

Closed cooling-water systems for the reactors, turbines, and associated components are not attractive sources of heat recovery for station heating because (1) the load on these water systems changes continuously during normal plant operation, with peak load lasting for only a short duration, and (2) the systems are not available for heat recovery during plant shutdown. Ventilation exhaust air provides a more dependable, continuous source of heat energy,

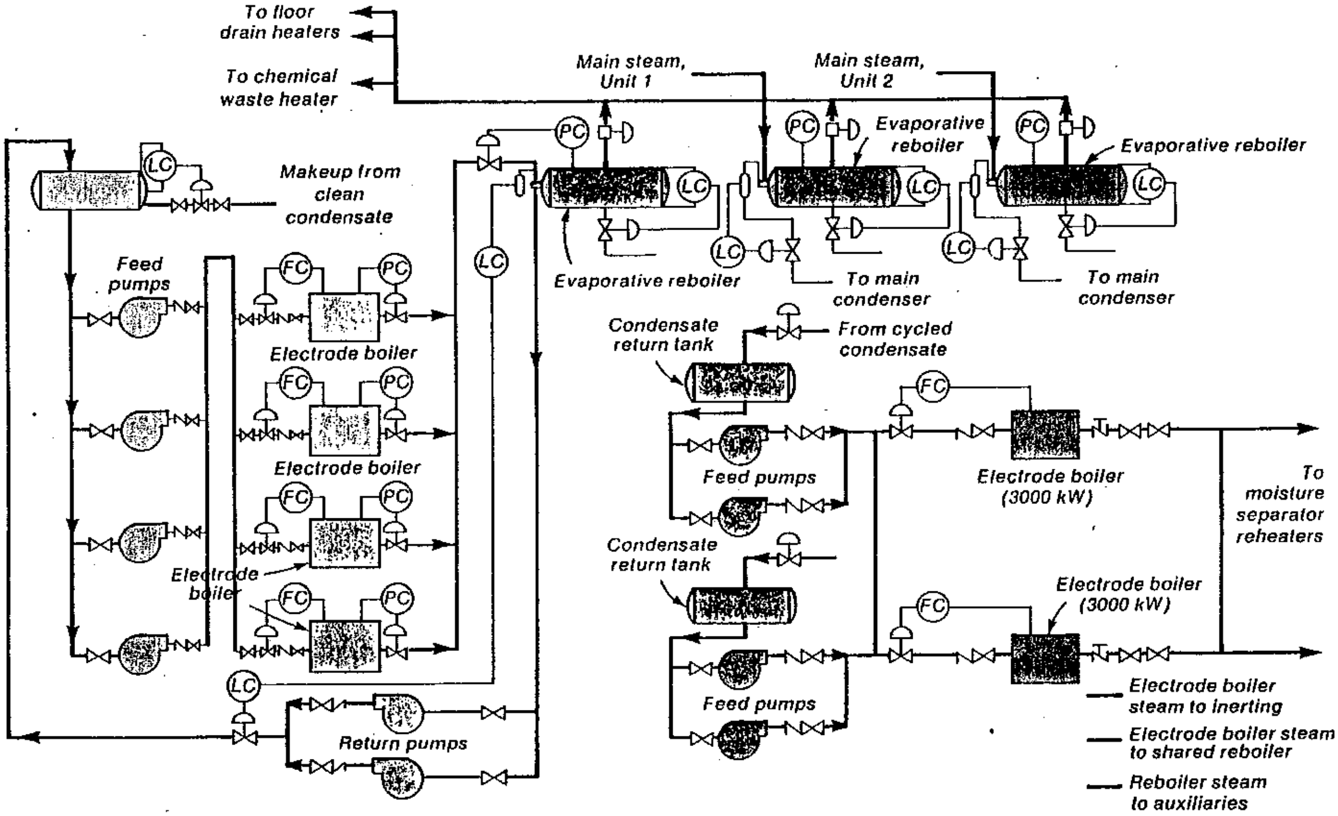


2. Heating requirements during three modes of operation; also, outside air temperatures at which the heat-recovery system is self-sustaining for each mode

conducive to the design of a self-sustaining system.

System design

An air-to-liquid-to-air heat-recovery loop between distant supply- and exhaust-air plenums is installed at LSCS. A solution of ethylene glycol (40%) in demineralized water is used as the heat-transfer medium. A conceptual design of the heat-recovery system is shown in Fig 1.



3. Auxiliary steam system consists of reboilers using main steam, and electrode boilers supplying steam to reboiler

Heat is recovered from the exhaust air of Units 1 and 2 reactor and turbine buildings, switchgear rooms, and the radwaste facility. Heat is recovered directly from ethylene-glycol-cooled condensers of the primary-containment chillers. The recovered heat is used to preheat ventilation air for the reactor and turbine buildings and to supply air for the radwaste facility. Ventilation air for the switchgear rooms is preheated by recirculating a part of the rooms' exhaust air back to supply.

The primary-containment chiller/condensers are provided with two coil bundles. One is used with the heat-recovery system containing the ethylene-glycol solution; the other with the service-water system, to dissipate heat when the recovery system is not in operation during the summer. Three-way control valves are provided with the ventilation-air preheat coils to control the coil leaving-air temperature for varying liquid temperatures.

Freeze protection. The leaving-air temperature at the supply inlet to the heat-recovery coils may be as low as 18F when the outside air temperature is −10F. This may result in frosting on the air side of the coils. Three-way control valves are provided in the ethylene-glycol lines downstream of the coils. These valves are controlled by individual pressure-differential controllers, sensing pressure across the corresponding heat-recovery coil. As higher than normal pressure is sensed across each coil, the glycol solution bypasses the coil, resulting in coil defrost.

Supplementary electric heat. The heat-recovery system is self-sustaining during normal station operation. However, supplementary heating is

Table 1: Unique features

Item	Amount
Heat-exchange surface of heat-recovery system, sq ft	1,265,115
Supplementary electric heating installed, kW	10,740
Total capacity of electrode boilers for generating auxiliary steam, kW	24,000
Estimated initial charge of 40% ethylene glycol aqueous solution, gal	22,000

Table 2: Economics of heat-recovery system

Item	Amount
Additional estimated investment cost (without indirects) at LSCS over conventional heating and auxiliary steam systems, $	1,810,000
Total levelized net savings in energy costs, $/yr	2,568,400
Annual percentage saving due to investment, %	[illegible]
Payback period for capital investment, yr	1

Table 3: Estimated peak heating requirements

Item	Requirements, million Btu/hr
Ventilation preheat	
Reactor building	
Unit 1	7.52
Unit 2	7.52
Turbine building	
Unit 1	20.90
Unit 2	20.90
Radwaste facility	6.99
Subtotal (A)	63.83
Transmission losses	
Unit 1 (B)	3.28
Unit 2	3.28
Subtotal (C)	6.56
Total heating	
Normal operation (A)	63.83*
One-unit outage (A + B)	67.11
Two-unit outage (A + C)	[illegible]

*Assumes that transmission heat losses are offset by equipment heat during unit operation required during these three abnormal modes of plant operation:

- One-unit outage, in which only the operating unit's equipment heat is available.
- Two-unit coincidental outage, in which equipment heat is not available.
- Cold plant startup.

Supplementary heat is provided by:

- Electric blast coils in the ventilation airstreams.
- Electric immersion heaters in the ethylene-glycol circulation stream.
- Electric unit heaters located at the perimeter of most buildings.

Energy balance

The energy balance and percent heat recovery for various modes of plant operations are shown in Tables 3 and 4. During normal plant operation, some 87% of the ventilation-heating requirements are recovered from exhaust air, the balance from primary-containment chillers. The system operates self-sustained, with no supplementary heating required.

During one-unit outage, the percent heat recovery is 78%; the heat-recovery system is self-sustaining with no added heat needed when the ambient air temperature is 5F and above (Fig 2). During two-unit outage, the percent heat recovery on a design day is 58% and the system is self-sustaining when the ambient air temperature is 20F and above.

Annual energy requirements are conservatively calculated based on a typical year's weather data, assuming a 60-day one-unit outage and a 30-day two-unit coincidental outage during worst-winter conditions. In actual practice, energy savings will be better if the outages are planned in less severe winter months.

Auxiliary steam system

Nuclear steam is used for radwaste processing and other auxiliaries at LSCS. This source was considered in Design A of the economic study, in conjunction with the heat-recovery system for station heating, because no other sources of steam generation were available. In the other two designs, the auxiliary steam system is common to both heating and process requirements.

A conceptual design of the auxiliary steam (AS) system is shown in Fig 3. Auxiliary steam at 50 psig is generated by three reboilers—one assigned to each unit, with the third being shared. The reboilers are also heated by 100-psig steam. Two reboilers use nuclear (main) steam; the common reboiler uses steam generated by four electrode boilers. The common reboiler is used only when nuclear steam is not available.

Also, two 3000-kW steam electrode boilers are available to supply inerting steam to the moisture-separator reheaters during reactor shutdown. The steam blankets the inter-

Units 1 and 2, LaSalle County Station, Morris, Ill, Commonwealth Edison Co

Steam-generation equipment

Boiling-water reactor, 1 per unit. . . . General Electric Co, Combustion Engineering Inc (Unit 1); General Electric Co, Chicago Bridge & Iron Co (Unit 2)
Overall vessel height, 72 ft-11 in.; inside diameter, 20 ft-11 in.; 800 tons; base material, low-alloy steel plate; cylindrical shell and hemispherical head clad with 0.125-in.-thick stainless steel; thermal output, 3293 MW; 14.166 × 10⁶-lb/hr steam flow at 1020-psia nominal steam-dome pressure; core approximates a right circular cylinder with a nominal central-portion outside diameter of 187 in. and an active-fuel height of 150 in.; average power density, 50 kW/liter; average heat flux, 145,208 Btu/hr-sq ft; 764 fuel assemblies, 62 fuel rods per assembly with a maximum linear heat generation of 13.4 kW/ft; Zircaloy-4 fuel-channel material with 0.032-in.-wall Zircaloy-2 fuel-cladding material; 0.410-in.-diam uranium-dioxide fuel pellets, 1.91-wt % average enrichment. Reactor is designed to achieve a first-core average discharge exposure of 10,300 MWd/T.
Twenty jet pumps circulate reactor coolant from recirculation pumps through fuel assemblies in the core and are capable of producing a total core flow of 106.5 × 10⁶ lb/hr. Steam-separator assembly is located inside the reactor vessel above the core. Steam dryers are located above the steam separator and remove moisture from the wet steam leaving the separators. In-core monitoring equipment includes the following: source-range, intermediate-range, local-power-range, average-power-range, and rod-block monitors and a traversing in-core probe system

Primary containment.................... Walsh Construction Co (concrete), Chicago Bridge & Iron Co (liner)
Primary containment is of an over-pressure and under-pressure-suppression design, constructed of post-tensioned concrete with a steel liner. Drywell is a right circular cylinder topped with a frustum of a cone and lined with carbon-steel plate. The pressure-suppression chamber (wetwell) is a right circular cylinder lined with stainless-steel plate. Both drywell and wetwell are designed for an internal pressure of 45 psig. Free volume of the drywell is 221,518 cu ft, free volume of the wetwell is 166,400 cu ft, and the wetwell water volume is 109,906 cu ft. Personnel access doors (interlocked) and an equipment hatch are provided

Recirculation pumps, 2.................................. Bingham-Willamette Co
Each 47,250 gpm at 850-ft head, 8340-hp motor drive

Recirculation-pump control valves, 2........ITT Hammel Dahl/Conoflow
Each 24 in., hydraulically actuated type

Control-rod drive system

Hydraulic control units, 185 per unit ....General Electric Co
Water pumps, 2 per unit..Undisclosed
Each centrifugal type, 100 gpm at 3678-ft head
Flow-control valves, 2 per unit..................ITT Hammel Dahl/Conoflow
Pressure-control valves, 2 per unit ....ITT Hammel Dahl/Conoflow
Stabilizing valves, 2 per unit.....................................General Electric Co
Pump suction filters, 1 per unit ....Dollinger Corp
Pump discharge filters, 2 per unit ....AMF Inc, Cuno Div

Reactor-water cleanup system

Main cleanup pumps, 3 per unit................................ Union Pump Co
Each centrifugal type, 180 gpm at 500-ft head
Regenerative heat exchangers, 2 per unit...... Atlas Manufacturing Co
Each three-stage design, 18-in.-diam × 25-ft-long type-304 stainless-steel shell, 86 0.75-in.-diam type-304 stainless-steel U-tubes, 1425-psig/575F tube design conditions
Nonregenerative heat exchangers, 2 per unit. . . . . . Atlas Manufacturing Co
Each two-stage design, 18-in.-diam × 31-ft-long A106 (Gr B) carbon-steel shell, 99 0.75-in.-diam type-304 stainless-steel U-tubes, 1425-psig/575F tube design conditions
Filter demineralization system ....Ecodyne Corp, Graver Water Div
Powdex resin type; three resin tanks arranged in parallel, each with a rated flow of 135 gpm; maintains conductivity of reactor water below 0.1 micromho/cm and undissolved solids below 10 ppb
Precoat tank, 1 per unit ....Ecodyne Corp, Graver Water Div
Precoat pump, 1 per unit .... Goulds Pumps Inc

Safety systems

High-pressure core-spray system (HPCS) is a standby safety system used to pump makeup water into the reactor vessel in the event of a coolant loss that is small enough to permit the primary system to remain at high pressure.
HPCS pump, 1 per unit ....Ingersoll-Rand Co
Centrifugal type, vertical orientation, eight stage, double suction, 6942 gpm at 662-ft head

Reactor-core-isolation cooling system (RCIC) provides makeup water to the reactor vessel when the vessel is isolated.
RCIC pump, 1 per unit .... Bingham-Willamette Co
625 gpm at 2850-ft head, 700/130-hp steam-turbine drive
RCIC-pump steam-turbine drive, 1 per unit ....Terry Corp

nal surfaces of the main steam system, thus protecting it from corrosion. This system is a closed vapor-cycle design.

Startup, steady-state operations. The AS system will be operated when steam is required for the radwaste evaporators and/or for inerting the main-steam systems. The reboilers can be operated during any planned plant operation, using either main steam or electrode boiler steam to heat the specific reboiler. The inerting-steam portion of the AS system is normally used during refueling and extended plant shutdowns, and for achieving criticality.

Energy consumption for the AS system is based on a 50% use factor and electrode-boiler use during two-unit coincidental outage for 30 days at worst-winter conditions. ■

This report was prepared by David C Haan, project manager, and P N Mehrotra, HVAC project supervisor, Sargent & Lundy.

Table 4: Estimated heat recovery from key sources during three plant operating conditions

Heat source	Heat recovery modes, million Btu/hr		
	Normal operation	One-unit outage	Two-unit outage
Reactor building exhaust			
Unit 1	4.54	4.54	3.36
Unit 2	4.54	3.36	3.36
Turbine building exhaust			
Unit 1	20.30	20.30	14.84
Unit 2	20.30	14.84	14.84
Radwaste facility exhaust	4.75	4.75	4.30
Switchgear room exhaust			
Unit 1	0.50	0.50	—
Unit 2	0.50	—	—
Primary containment chiller			
Unit 1	4.20	4.20	—
Unit 2	4.20	—	—
Total	63.83	52.49	40.70
Percent heavy recovery = Heat recovered* / Heat required** × 100	100%	78%	58%

*In million Btu/hr. **In million Btu/hr, as given in Table 1

Single-wheel type, 1105/135-psig inlet pressure, 5150/33,000-lb/hr steam flow, 25-psia exhaust pressure

Pressure-relief system consists of 18 safety/relief valves mounted on the main steam lines and prevents excessive pressure in the boiling-water reactor following operational transients.

Safety/relief valves, 18 per unit .... Crosby Valve & Gage Co
Relief-valve settings vary between 1076 and 1116 psig, safety-valve settings vary between 1130 and 1205 psig, seven valves provide automatic depressurization capability

Residual-heat removal system (RHR) can be divided into three separate systems which function independently, but use the same major equipment. These are the (1) low-pressure coolant-injection, (2) reactor-shutdown cooling, and (3) containment cooling systems

RHR pumps, 3 per unit .... Ingersoll Rand Co
Each centrifugal type, vertical orientation, three stage, double suction, 7450 gpm at 280-ft head

RHR heat exchangers, 2 per unit .... Struthers Wells Corp
Each rated 1.68 × 10⁸ Btu/hr in the containment-cooling mode, vertical orientation, shell-and-tube type, 52 in. diam × 36.75 ft high

RHR service-water pumps, 4 per unit .... Crane Co, Deming Div
Each centrifugal type, horizontal orientation, single stage, double suction, 3000 gpm at 279-ft head

Low-pressure core-spray system (LPCS) is a low-pressure system designed to spray water into the core automatically to prevent damage to the fuel bundle in the unlikely event that a large amount of coolant is lost from the primary system.

LPCS pump, 1 per unit .... Ingersoll Rand Co
Centrifugal type, vertical orientation, five stage, double suction, 8350 gpm at 725-ft head

Standby liquid control system is designed to shutdown the reactor from full power to a subcritical condition in the event the control-rod drive system becomes inoperable.

Tank, 1 per unit .... Lamco Industries Inc
Holds 5150 gal of a 13.4% solution of sodium pentaborate at atmospheric pressure; two electric immersion heaters and a temperature-control system automatically maintain temperature at 80-85F to prevent precipitation of sodium pentaborate from the solution during storage; minimum design injection rate of the system is 39 gpm

Injection valves, 2 per unit .... Undisclosed

Pumps, 2 per unit .... Union Pump Co
Each positive-displacement type, 42 gpm at 1225 psig

Standby gas-treatment system (SGTS) maintains a negative pressure in the secondary containment (reactor building) and provides a means for minimizing the release of radioactive material from the containment to the environs by filtering and exhausting air from the reactor building during containment-isolation conditions. Elevated release is assured by an SGTS exhaust pipe, located inside the plant's vent stack, which has an effluent discharge velocity of more than 1000 ft/min. A two-train system serves the plant, with the following components in each train:

Housing, 1 .... CVI Corp
The nominal 4000-cfm filter housing is designed to rigidly support all the components so they can withstand a design pressure differential of 1 psig. It is of all-welded construction (0.25-in.-thick carbon-steel plate and carbon-steel structural members) and has marine-type access doors, compartment drains, compartment lights, DOP and Freon test ports, and instrumentation

Moisture separator, 1 .... CVI Corp
Removes 99% (on count basis) of entrained moisture droplets 1 micron and larger; unit, qualified to MSAR-71-45, meets requirements of UL-900, Class I

Electric heater, 1 .... CVI Corp
Reduces the relative humidity of the air to 70% when these, or more favorable, air-inlet conditions prevail: 150F (dry bulb), 100% relative humidity. Heater's heating elements have an Inconel sheath and type-304 stainless-steel fins; frame, terminal box and heating element supports also are constructed of type-304 stainless steel

Prefilter, 1 .... CVI Corp
Minimum efficiency of 90% in accordance with ASHRAE standard 52-68, meets requirements of UL-900, Class I

HEPA filters, 2 .... CVI Corp
Each removes 99.97% of radioactive particulates 0.3 microns and larger; meets requirements of MIL-F-51068D, MIL-F-51079B, MIL-STD-282, and UL-586

High-efficiency carbon-adsorbtion systems, 1 .... CVI Corp
Removes radioactive and nonradioactive methyl iodide (CH_3I) and elemental iodine using potassium-iodide-impregnated carbon. The vertical-bed adsorbers are of welded construction with 8-in.-thick carbon layers, which provide an air residence time of 1 sec to assure an efficiency greater than 99%

HVAC systems insure habitable conditions in the main control room and proper operation of control-room equipment under all the plant operating conditions. This includes protection of personnel from fire, smoke, radiation, chlorine, and ammonia, any or all of which may be present outside the control room. A two-train system serves the control room, with the following equipment in each train:

Air-handling units, 2 .... Carrier Corp
Each blow-through type with a direct-expansion refrigerant coil in the cold deck and an electric heating coil in the individual zone ducts. Direct-expansion coils, arranged in six rows and of split design, use Freon-22 and have 10 fins/in. Housing is constructed of 11-gage galvanized sheet metal

Supply-air filter unit, 2 ....Undisclosed
Each consists of a high-efficiency air filter and an impregnated-carbon absorber with bypass and isolation dampers; filters recirculated air, or a mixture of outside and recirculated air, from the control room; has a 90% minimum efficiency rating in accordance with ASHRAE standard 52-68. Carbon absorbers, designed to remove odor and smoke, are of vertical-bed welded construction with 2-in.-deep charcoal sections; air residence time is 0.125 sec

Refrigeration units and air-cooled condensers, 2 each .. Carrier Corp
Each consists of a direct-coupled reciprocating compressor and control-panel assembly with a remote air-cooled condenser. The direct-expansion coil has a hot-gas bypass; condenser-capacity controls are of the flood-back type

Emergency makeup air-filtration units, 2.......................... CVI Corp
Each consists of a moisture separator, heating coils, prefilter, HEPA filter, charcoal bed, and HEPA filter; removes all of the radioactive particulates or iodine present in the outside makeup air for the control room

Tornado check dampers, 2..Techno Corp
Installed in the control-room outside-air intake duct, they protect the control room and its equipment from the positive and negative effects of a tornado

Heat-recovery system

Ventilation preheat coils .... Carrier Corp
Two preheat coils are installed in the reactor-building ventilation system, each rated 110,000 cfm and 7.52 × 10⁶ Btu/hr; four are installed in the turbine-building ventilation system, each rated 150,000 cfm and 10.45 × 10⁶ Btu/hr; one is installed in the radwaste-facility ventilation system, rated 96,000 cfm and 6.99 × 10⁶ Btu/hr

Exhaust-air heat-recovery coils .... Carrier Corp
Two coils are installed in the reactor-building ventilation system, each rated 110,000 cfm and 4.54 × 10⁶ Btu/hr; two are installed in the turbine-building ventilation system, each rated 300,000 cfm and 20.3 × 10⁶ Btu/hr; three are installed in the radwaste-facility ventilation system, each rated 48,000 cfm and 2.38 × 10⁶ Btu/hr; one is installed in the switchgear ventilation system, rated 60,000 cfm and 0.614 × 10⁶ Btu/hr

Glycol heaters, 2 ....CAM Industries Inc
Each 1000 kW, 480 V, three phase, 60 Hz

Drywell chillers, 4 .... Carrier Corp
Each hermetic centrifugal, liquid type using Freon-12; double-bundle shell-and-tube condenser (for glycol and water service); flooded-type evaporator; 6.6 × 10⁶-Btu/hr cooling capacity; 8.4 × 10⁶-Btu/hr heat-rejection capability

Supplemental heating system.. Gould Inc;
Emerson Electric Co, Chromalox Div
Consists of 225 electric unit heaters, plus two electric blast-coil banks in the reactor-building ventilation system, each rated 800 kW, 480 V, three phase, 60 Hz; four electric blast-coil banks in the turbine-building ventilation system, each rated 800 KW, 480 V, three phase, 60 Hz; and one electric blast-coil bank in the radwaste-facility ventilation system, rated 800 kW, 480 V, three phase, 60 Hz

Auxiliary steam systems

Electrode boilers, 4..CAM Industries Inc
Each 4500 kW, 6.9 kV, three phase, 60 Hz

Inerting-steam electrode boilers, 2 ....CAM Industries Inc
Each 3000 kW, 6.9 kV, three phase, 60 Hz

Evaporative reboilers, 3 .... Unitech Manufacturing Corp
Each high-temperature, shell-and-tube type; two units rated 40,000 lb/hr at 50 psig/297F, one 60,000 lb/hr at 65 psig/297F

Radwaste processing system

The liquid-radwaste system consists of several major subsystems, each designed to process a different type of waste. The waste characteristics and the degree of treatment associated with each subsystem is as follows: (1) low-conductivity waste from the waste-processing subsystem is treated by settling, filtration, and ion-exchange demineralization; (2) low-purity, high-conductivity waste from the floor-drains processing subsystem is treated by evaporation and ion-exchange demineralization; (3) very-high-conductivity waste from the chemical-waste subsystem is treated by chemical neutralization, evaporation, and ion-exchange demineralization; (4) waste from the laundry-waste subsystem is treated by filtration and reverse osmosis. Wastes processed by these subsystems are sampled and analyzed. If satisfactory for reuse, they are transferred to the condensate storage tank—that is, unless plant water-balance requirements dictate that they be discharged from the station.

Another part of the radwaste processing system is the sludge subsystem. It consists of a group of tanks and pumps which provide intermediate storage for slurries produced by the radwaste decontamination equipment, and by other radioactive-liquid cleanup systems, prior to transferring them to the solid-radwaste handling system. The solid radwaste system receives, solidifies, packages, handles, and provides temporary storage facilities for the wet solid wastes produced at the station before it is shipped off-site for disposal.

Radwaste demineralizers, 5 per unit .... Illinois Water Treatment Co
Each of the mixed-bed demineralizers uses regenerable nuclear-grade resins; two units are rated 300 gpm, three are rated 75 gpm

Radwaste filters, 2 per unit .... Croll-Reynolds Engineering Co
Each 300 gpm, precoat type, diatomaceous-earth filter medium

Radwaste evaporators, 3 per unit .... Ecodyne Corp, Unitech Div
Each forced circulation, 300 gpm, 21,000-lb/hr steam requirement

Solid radwaste stations, 2 per unit .... Stock Equipment Co

Miscellaneous tanks .... Chicago Bridge & Iron Co,
Continental Boiler Works Inc, Niles Steel Tank Co

Miscellaneous pumps .... Goulds Pumps Inc, Robbins & Myers Inc

Turbine/generator and auxiliaries

Turbine/generator, 1 per unit......................................General Electric Co
Tandem compound, six flow, reheat, 38-in. last-stage blades, 14,151,068 lb/hr of steam at 965 psia/540F, 1-in.-Hg-abs backpressure. Steam is admitted to the horizontal, double-flow, extraction, high-pressure turbine via four stop valves and four control valves. It exhausts at 164.4 psia and 13% moisture to two, two-stage moisture separator/reheaters, which supply three horizontal, double-flow, extraction, low-pressure turbines via six combination stop/intercept valves. The three-phase, 60-Hz, 1800-rpm, wye-connected generator is rated 1119 MW (net) at 75-psia hydrogen pressure, 0.9 power factor, 0.58 short-circuit ratio. Stator and rotor weights are 375 and 204 tons, respectively. Exciter is rated 2250 kW, 500 V, 4244 amp

Moisture separator/reheaters, 2 per unit ....General Electric Co

Main condenser, 1 per unit ....Westinghouse Electric Corp

Steam-jet air ejectors, 2 per unit ....Graham Manufacturing Co

Condenser off-gas treatment system

Free hydrogen in the condenser off-gas is combined with oxygen by catalytic recombiners and dehumidified using condensing heat exchangers. It is processed further through high-efficiency filters, holdup piping, and charcoal absorbers before being discharged through the plant stack.

Off-gas preheaters, 2 per unit .... Whitlock Manufacturing Co
Each has a carbon-steel shell designed for 350-psig/400F service and stainless-steel tubes designed for 1000-psig/575F service

Catalytic recombiners, 2 per unit. . . .
. . . .Universal Oil Products Inc, Air Correction Div
Each has a stainless-steel cartridge containing a precious-metal catalyst on nichrome strips (cartridge is replaceable without removing the vessel), Cr/Mo-steel shell designed for 350-psig/900F service

Off-gas condensers, 2 per unit.................. Whitlock Manufacturing Co
Each has a Cr/Mo-steel shell designed for 350-psig/900F service and stainless-steel tubes designed for 250-psig/900F service

Water separators, 2 per unit .... Process Equipment Co,
Each has a carbon-steel shell designed for 350-psig/250F service and stainless-steel wire mesh

30-min holdup pipe...Undisclosed
Carbon-steel pipe, radiographed and buried, has outside surface wrapped and coated for corrosion protection; ends and elbows are reinforced to withstand 1000-psig/150F conditions

Cooler/condensers, 2 per unit ....General Electric Co
Each has a stainless-steel shell designed for 350-psig/150F service and stainless-steel tubes designed for 100-psig/150F service

Moisture separators, 2 per unit ....Process Equipment Co
Each has a carbon-steel shell designed for 350-psig/150F service and stainless-steel wire mesh

Off-gas reheater, 1 per unit ....General Electric Co
Consists of carbon-steel pipe with electric resistance heaters mounted on the outside of the pipe

Glycol refrigeration machines, 2 per unit. . . .
. . . .Cordon International Corp, Cosmodyne Div

Prefilters and afterfilters, 2 each per unit .... CVI Corp
Each has a carbon-steel shell designed for 350-psig/130F service and a moisture-resistant HEPA filter element

Carbon-bed adsorbers, 8 beds per unit ...... Process Equipment Corp
Each consists of a 4-ft-diam × 21-ft-long carbon-steel shell containing a 16-ft packed section with 3 tons of 8-14-mesh carbon (Columbia G or equivalent)

Emergency electrical system

Diesel/generators, 5 .... Stewart & Stevenson Services Inc
Two diesel/generators serve each unit; one is shared between the units. Each is rated 2860 kW, 0.8 power factor, 4.16 kV, three phase, 60 Hz for 2000 hr/yr; 2987 kW for 168 hr; 3040 kW for 0.5 hr