DAB

Wayne H. Jens
Vice President
Nuclear Operations

Detroit Edison

Fermi-2
6400 North Dixie Highway
Newport, Michigan 48166
(313) 586-4150

June 14, 1985
VP-85-0136

Mr. James G. Keppler
Regional Administrator
Region III
U. S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Dear Mr. Keppler:

Reference: Fermi 2
NRC Docket No. 50-341
NRC License No. NPF-33

Subject: Detroit Edison Response
Inspection Report 50-341/85-15

This letter responds to the open item described in your Inspection Report No. 50-341/85-15. This inspection was conducted by Messrs. S. DuPont, S. Guthrie, S. Stasek, T. Tongue, and N. Chrissotimos on March 4 through 6, 1985.

We trust this letter satisfactorily responds to the open item described in the inspection report. If you have questions regarding this matter, please contact Mr. Lewis Bregni, (313) 586-5083.

Sincerely,

Wayne H. Jens

cc: P. M. Byron
N. J. Chrissotimos
USNRC, Document Control Desk
Washington, D.C. 20555

bcc: F. E. Agosti
R. W. Barr
M. L. Batch
E. R. Bosetti
W. F. Colbert
L. B. Collins
O. K. Earle
C. R. Gelletly
W. J. Glasser
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F. T. Schwartz
L. J. Simpkin
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Secretary's Office (2412 WCB)

THE DETROIT EDISON COMPANY

FERMI 2

NUCLEAR OPERATIONS ORGANIZATION

RESPONSE TO NRC INSPECTION REPORT NO. 50-341/85-15

DOCKET NO. 50-341 LICENSE NO. NPF-33

INSPECTION AT: FERMI 2, NEWPORT, MICHIGAN

INSPECTION CONDUCTED: MARCH 4-6, 1985

RESPONSE TO NRC INSPECTION REPORT 50-341/85-15

Description of Open Item 85-15-01

This open item involves two concerns with the Fermi 2 electrical distribution system. The first concern is that the electrical distribution system, as constructed, does not appear to meet the requirement for two physically independent circuits from the offsite transmission network to the onsite electrical distribution system, as specified in General Design Criterion 17 of 10CFR50 Appendix A. The second concern is that the separation of the offsite power sources reduces plant safety by increasing the chance of plant transients and challenges to safety systems due to a loss of either offsite network.

Detroit Edison Response

The Detroit Edison electrical distribution system design maintains separation through our offsite electrical system, so that our 120 kV and 345 kV switchyards are not tied together locally. The 120 kV switchyard has three independent incoming lines, while the 345 kV switchyard has two independent incoming lines. We feed one division of Class IE power via a transformer from the 120 kV switchyard and the other division via a transformer from the 345 kV switchyard. Therefore, each division of Class IE power is normally supplied by at least two (2) physically independent circuits from the transmission network. This independence reduces the possibility that offsite AC power would be lost, thereby reducing the susceptibility of Fermi 2 to station blackout. This configuration goes well beyond the requirements of GDC 17 and its acceptance is documented in Section 8.1 of the Fermi 2 Safety Evaluation Report. In addition, IEEE Standard 765-1983, "IEEE Standard for Preferred Power Supply for Nuclear Power Generating Stations", shows and discusses several examples of an acceptable preferred power supply design. Figures 2(a) and (b) of that standard illustrate a similar system to ours in that each class IE bus has a single feed from the non-class IE system with multiple lines feeding the non-class IE bus. The only variation between the figures in the standard and the Fermi 2 design is that we transform the offsite transmission power after the non-class IE bus instead of before.

Detroit Edison Response (Cont'd)

The inspector noted that the loss of either transformer would impose an undesirable transient on the unit, unnecessarily challenge safety systems and challenge the emergency diesel generators. He indicated that station reliability could be enhanced by employing an automatic transfer between the two offsite power sources to provide feeds to each division of Class IE power. Detroit Edison contends that the use of automatic transfers would reduce the reliability of our offsite power sources thereby reducing the inherent level of safety provided by our Class IE power system. A summary of the historical basis for this position, which included evaluation of reliability and other considerations (effecting both safety and economics), follows.

For many years Detroit Edison power plant auxiliaries were supplied directly from the terminals of the generator by an auxiliary transformer and required another external source for startup of the unit. After the generator was synchronized and capable of taking the load, the auxiliaries were transferred from the external source to the generator terminal auxiliary transformer. Likewise, for a normal shutdown, the automatic throwovers transferred the auxiliaries to the external source. This scheme, with its undervoltage relays, timers, interlocks etc., was difficult to make entirely reliable. As generating units increased in size, the hazards possible with throwovers and transfers greatly increased. With the design of our Trenton Channel No. 9 Unit in 1966, this operating philosophy was reviewed, which led to a change in operating philosophy: the throwovers would be abandoned and the high voltage switchyard would be the source of supply to the auxiliaries. An auxiliary (System Service) transformer so connected would prove as reliable as the generator transformer. If the high voltage bus were not available the unit would not be available and therefore, the auxiliaries would not be required. The System Service Transformer, fed from the high voltage switchyard has been used on the last ten generating units added to the Detroit Edison grid with very reliable success. The change in philosophy is detailed in IEEE paper 31PP66-549.

During the initial design for the Fermi 2 plant, the use of a machine fed auxiliary transformer versus transmission system fed transformer was again discussed. It was concluded that the use of a system service transformer

Detroit Edison Response (Cont'd)

(transmission system fed) offered the best advantages and thus was adopted as the acceptable design for the plant auxiliaries because of:

- Simplicity of design,
- Less expensive,
- Better operating convenience,
- Good reliability

Because Fermi 2 is a nuclear plant and General Design Criterion 17 requires "Electrical power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits... designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions," our second feed was taken from the onsite 120 kV switchyard using the principles of the system service transformer design. At that time, it was recognized that the loss of either the 120 kV switchyard or the 345 kV switchyard would most likely result in a unit trip. However, this design was judged acceptable based on an evaluation of factors which could affect safety, reliability, and availability, as follows.

1. Auxiliary power system integrity was considered good because most situations forcing unit shutdowns are associated with the units themselves.
2. The elimination of transfers and auto-throwovers made it a simpler and safer system.
3. Both high voltage buses are fed by multiple transmission lines.
4. Spare transformers are available.

Detroit Edison Response (Cont'd)

5. Failure probabilities were considered for the major components, including transformers, cables, and terminations.

A copy of the discussion notes for the March 19, 1971 design meeting documenting these considerations is available for your review.

Detroit Edison, Transmission Planning Group, has determined the probability and duration for loss of the offsite power sources for the Fermi plant.

A copy of this calculation (July 20, 1981) is also available for your review. Based on this calculation, the reliability of the offsite power feeds to Fermi 2 is considered to be acceptable.

Detroit Edison believes our method of providing power to the class IE divisional buses meets the requirement of GDC 17 for providing two independent offsite power sources and poses no undue challenges to safety systems.

FILE (JLV)
☒ EXISTING ☐ NEW
P-TC9-1.0

Here's a history of DE's auxiliary system & the development of auxiliary system used at TC9 & later units

JLV MAR 16 '83

TRENTON CHANNEL NO. 9 - A CHANGE IN PHILOSOPHY - IN SUPPLIES TO AUXILIARIES

W. J. Campbell
Member IEEE

J. L. Voyles
Member IEEE

Both of:
The Detroit Edison Company
Detroit, Mich.

A paper recommended by the IEEE Power Group for presentation at the 1966 ASME/IEEE Joint Power Generation Conference, Denver, Colorado, September 18-22, 1966. Manuscript submitted August 2, 1966; made available for printing August 3, 1966.

Price: $1.00
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Paper No.
31 PP 66-549

TRENTON CHANNEL No. 9 - A CHANGE IN PHILOFOPHY - IN SUPPLIES TO AUXILIARIES

W. J. Campbell J. L. Voyles
Member IEEE Member IEEE

THE DETROIT EDISON COMPANY
DETROIT, MICHIGAN

SUMMARY

The engineering of the electrical auxiliary system for Trenton Channel No. 9 is based on a major change in the philosophy of designing auxiliary electrical systems. A single transformer connected to the unit high voltage bus will supply the major auxiliaries for the unit. Major features of the auxiliary system are described.

INTRODUCTION

The addition of the 500 Mw turbine generator No. 9 to the Trenton Channel Power Plant will be the second major expansion of this plant. The engineering of the electrical auxiliary system for this addition is based on a major change in the philosophy of designing auxiliary electrical systems. This change in philosophy is based on many of the same factors that have been important in the engineering and selection of all power plant equipment, many of which have shown large engineering advances and changes over the years. Before discussing this change in philosophy, it would be desirable to study the development of auxiliary systems. A review of the existing Trenton Channel Power Plant design provides a good example of auxiliary system development in The Detroit Edison Company system.

EXISTING PLANT DESCRIPTION

Original Installation

The original installation at Trenton Channel included six 50 Mw turbine generators and thirteen boilers which were combined to supply steam to the turbine throttle at steam conditions of 400 psig and 725 F. This part of the plant was completed in the mid 1920's. The plant was planned before the introduction of the Company's major high voltage transmission lines and was located in a remote area. Auxiliary power was provided by house service generators at a voltage of 240 v d-c connected through a common house service bus. House service power provided the reliability for the auxiliaries and d-c power supply provided a suitable means of speed control for pumps and fans. This plant was also one of the first in The Detroit Edison Company to burn pulverized fuel and a separate building was provided for the pulverizing equipment. All coal handling equipment was driven by a-c motors with house service generators and one tie from the Company's transmission system serving as the power supply. This system is shown in Figure 1.

This plant was capable of supplying its own auxiliaries. A gradual trend toward a-c power for all auxiliaries, with ties from both the transmission system and terminal transformers was established in plants constructed at a later date in the Detroit Edison system.

First Plant Expansion

The first expansion of the Trenton Channel Power Plant occurred in 1950 and included two 100 Mw turbine generators supplied by four headered boilers. The steam conditions of these units are 1380 psig and 950 F. This addition represented a substantial increase in unit size and also unit auxiliary load. Investigations were made to determine the advisability of expanding the existing d-c system or providing a new a-c auxiliary system. With the added power requirements, d-c power investment costs were increasing greatly so that it could not be justified as a source of speed control. Alternating current power was less expensive and its reliability had been improved because of the high voltage transmission system that tied all power plants together. Thus, a-c power was selected for all auxiliaries. The design of a-c auxiliary systems for these two units was based on maintaining auxiliary power to the unit for both system disturbances and possible problems in the transformer supplying the auxiliary system. The first requirement was met by connecting auxiliary transformers to the generator terminals. The second requirement was met by standby transformers (called system service transformers) connected to the transmission system with autothrowovers from the auxiliary transformer to the system service transformers. Generator breakers were provided so that transfer of auxiliaries would not be required for each startup and shutdown of the unit. This basic system is shown in Figure 2. This system operated at 2400 v a-c, which was in use in the existing plant, and provided a convenient means of establishing the backup requirements previously described.

Subsequent Developments

When this section was complete, the total capacity of Trenton Channel Power Plant was 500 Mw. This represented about 30 per cent of the Detroit Edison system at that time so the next expansion of the Company's power generation facilities took place at two new power plant sites. The unit size at these new plants increased gradually to 325 Mw and steam conditions rose to 2400 psig 1050/1000 F. The unit scheme of boiler and turbine was applied to these new units and many developments in power plant technology were made. The auxiliary system voltage rose to 4160 volts with the same basic requirements as the first expansion at the Trenton Channel Power Plant. The major change in these later units was the elimination of the generator voltage breaker because of the technical problems in handling large currents. This development placed added emphasis on the system service transformer because it then became necessary to transfer auxiliaries for each start-up and shutdown of the unit. The system service transformer also provided back-up for the unit auxiliary transformers but failure of the system service transformer would also jeopardize the unit because the unit could not be restarted after a shutdown. Thus, backup was also required for the system service transformer. This backup was provided by installing at least two system service transformers for each group of units in a plant that had a common auxiliary system voltage.

Second Plant Expansion at Trenton Channel

The second plant expansion at the Trenton Channel Power Plant will be the addition of Unit No. 9 and the design will follow the Company and industry practice of the unit turbine-generator and boiler installation. The 500 Mw rating will double the nameplate rating of the plant. The unit is scheduled for service in October of 1967. Steam conditions will be 2400 psig 1000/1000 F.

In developing the auxiliary system for Trenton Channel No. 9, it was recognized that a thorough review should be made of existing practices and philosophy in supplying power to the auxiliaries for this installation. Previous unit installations have generator terminal transformers supplying the unit auxiliaries. Startup, shutdown, and backup services are provided by transformers fed from the power plant's high voltage bus. The gradual change from house service supply to dependency upon the high voltage transmission system for unit auxiliaries suggested that this review of the philosophy of auxiliary system supply could produce new concepts in the supply of auxiliary power.

BASIC PHILOSOPHY DEVELOPMENT

The continuity of output of a generating unit is directly dependent on the continuity of the auxiliaries which drive it, therefore, its reliability is no greater than that of its auxiliaries. Consequently, designing a firm and reliable source of power supply to the auxiliaries has always been a prime consideration of a power plant planning engineer.

Earlier Auxiliary Systems

As shown previously, earlier power plant auxiliary systems were usually one large interconnected system with the power supplied from house generators. When a-c power was supplied for auxiliaries, the auxiliary system had additional ties from the switching station which the generators supplied. These systems were very expensive and the possibility existed that electrical trouble in the area of one generating unit could spread to that of another unit or that the whole plant could be cascaded down.

This led to the adoption of the unit system whereby the auxiliaries of each unit are normally supplied directly from the terminals of the unit's generator. It was reasoned then that trouble on the auxiliaries of a unit should affect only that unit. However, with this type of system, the auxiliaries were required to be started from another source external to the unit. After the generator had been synchronized and was capable of taking on load, the auxiliaries were transferred from the external source to the generator terminal source. Likewise on normal shutdowns, auto-throwovers transferred the auxiliaries to the external source. The philosophy of operation was that fans, condensate pumps, boiler feed pumps etc., were required to be operating even on forced shutdown. Numerous papers in IEEE literature have been written describing how best to accomplish these auto-throwovers and transfers.

Throwovers and Transfers Make It Vulnerable

This scheme, with its under voltage relays, timing relays, auxiliary relays, transfer switches, interlocks and auxiliary contacts etc., is difficult to make entirely reliable. Redundancy built into the system also made it vulnerable to human error, and equipment often was damaged due to malfunctioning. As units further increased in size, the hazards possible with throwovers and transfers greatly increased. It became increasingly expensive to furnish such a system with sufficient backbone in it to support the great inrush of power which occurs on these auto-throwovers.

Questioning Operating Practice

This led Edison engineers to question our operating practice. Were auto-throwovers really necessary? Was it really essential that the auxiliaries continue to be supplied on a unit being forced down? When a unit is forced down, the fires and ignition are always extinguished immediately and since modern steam generators have comparatively little residual heat stored in them, there is little need for condensate pumps, boiler feed pumps etc., to be kept operating. The fans of modern units have very high inertia and they keep turning rapidly for some time after they lose their source of power.

This in itself coupled with the effect of the stack would quickly clear the gasses from the steam generator. Also, on a restart, steam generators are always purged before refiring. Reasoning thus, it became apparent that the unit could be shut down safely on loss of auxiliary power and little could be found to justify auto-throwovers.

New Philosophy

This led to a change in operating philosophy. Auto-throwovers would be abandoned. If a unit was forced down, it would be shutdown completely. On restart, the auxiliaries would be started properly in sequence. A review of shutdowns of generating units revealed that outages were caused by troubles within the turbine generator, steam generator, valves, exciter etc., and rarely, if ever, in the generator transformer or the unit high voltage bus. It was reasoned -- why not select the unit's high voltage bus as the source of supply to the auxiliaries? An auxiliary transformer so connected would prove as reliable as the generator transformer. If the unit high voltage bus were not available, the unit would not be available and the auxiliaries would not be required. This connection would still be considered a unit system of supply to the auxiliaries because the unit high voltage bus can be considered as part of the unit. Maintenance on the transformer can easily be accomplished with scheduled and unscheduled outages of the unit.

With the basic auxiliary power system requirements fulfilled by a single transformer, the only remaining question is that of transformer reliability as it relates to the entire unit reliability. The auxiliary transformer reliability is essentially the same as the generator transformer. Generator transformer reliability has been depended on where the common industry practice has been to install a single three phase transformer to step up the generator voltage to the system high voltage bus. This same dependency is extended to the auxiliary transformer for this auxiliary system. Spare generator transformers have not been carried for The Detroit Edison Company system, but this policy is being reviewed within the Michigan Power Pool. Costs of a spare generator transformer to cover many pool units could be shared on a pool basis. It is also planned to study auxiliary transformers for large units on the same basis.

Basic Conclusions

As a result of this philosophy development, the basic auxiliary power requirements can be satisfied by a single transformer connected to the unit high voltage bus. No backup or throwovers are required. All major unit auxiliaries would be supplied from this source.

Some small amount of power would be required for outage of the transformer for essential a-c service and during transformer maintenance work. This power can be supplied by a small low voltage bus with auto-throwovers to another source. This source can be obtained from existing plant services if available, from outside plant connections, or from automatic start Diesel driven generators.

This system is exceedingly simple and straightforward. When costs are compared to previous practices, the resultant savings become substantial. For a single unit installation at an existing plant, the savings result from the elimination of the generator terminal transformers, connections from these transformers, auto-throwovers etc. If transformer reliability remains questionable, the single unit installation would require two system service or startup transformers because failure of a single transformer installation would result in ultimate shutdown of the unit. There are, of course, added costs and losses in the generator transformer, but these are small in the incremental cost of the transformer and in capitalized losses when compared to the savings mentioned above.

For the large multi-unit plant, it should also be recognized that the savings of this plan would diminish because the costs of startup transformers and bus connections would be spread between several units.

TRENTON CHANNEL No. 9 AUXILIARY SYSTEM

As a result of the revisions in basic philosophy, the unit auxiliaries for Trenton Channel No. 9 will be served from one transformer connected to the unit high voltage bus and located close to the power plant wall beside the generator transformer as shown on Figure 3. There will be no throwovers or transfers of the power supply to main auxiliaries. The elimination of transfers relieves the operating personnel of a major operating step during each startup and shutdown and they are enthusiastic about this simplification in operating procedure.

Boiler Feed Pumps and Motor Driven Auxiliaries

The economic study of the various means of supplying boiler feed pump power (motors with hydraulic couplings, shaft driven pumps with hydraulic couplings and turbine driven pumps with inherent speed control) resulted in the selection of two half size turbine-driven, boiler-feed pumps for this unit. This relieved the auxiliary system of a large amount of load. All other auxiliaries (fans, pumps, compressors, etc.) are driven with a-c squirrel cage motors with flow or volume control accomplished by other means. A list of these main auxiliaries is shown in Table I.

Auxiliary System Voltages

The auxiliary system voltage was selected at 4160 volts. The elimination of transfers and throwovers made ties to the existing 2400 system unnecessary and the amount of auxiliary load for Unit No. 9 could be handled easily at 4160 volts. Motors above 200 hp will be fed directly from this 4160 v system. The smaller motors, lighting and other services will be supplied at 480 volts.

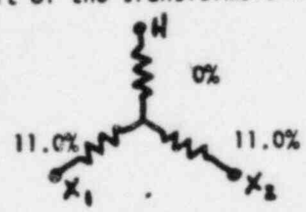
Auxiliary Transformer

A single auxiliary transformer has been specified with one high voltage winding at 123 kv, and two low voltage windings at 4160 volts. The rating will be 22.5/30 Mva, OA/FA. Because the high voltage bus varies from 120 kv to 132 kv, the transformer will be equipped with load tap changing (LTC). The LTC equipment has been selected to maintain 4160 volts on the auxiliary bus, regardless of the actual system voltage or the load on the transformer. By controlling the secondary voltage "through the iron", a single low voltage tap changer will control both low voltage windings at the same time. The control of the secondary voltage allows the use of standard motors on all auxiliaries. By establishing the initial voltage before starting at 104 per cent of motor voltage by LTC regulation, the motor voltage when starting will be above 90 per cent. The LTC equipment will be regulated by hand.

The impedance of the transformer was specified as follows on the 22.5 Mva base of the transformer.

$ZH\text{-}X_1$	11.0%
$ZH\text{-}X_2$	11.0%
$ZX_1\text{-}X_2$	22.0%

This will provide a zero leg on the equivalent circuit of the transformers which becomes:



With this equivalent impedance diagram, motors on one low voltage winding will not affect the switchgear rating for the other winding. The impedance was also required to have a tolerance of 7.5 per cent which is better than the 10 per cent normal tolerance of a three winding transformer.

The low voltage LTC equipment also varies the impedance considerably when the impedance is corrected to the actual voltage being maintained on the secondary of the transformer. To inhibit this impedance variation the transformer has been provided with a special series low voltage winding to limit this variation to plus or minus 10 per cent.

The transformer will receive impulse and corona tests as acceptance checks on the manufacture of the transformer.

Auxiliary Switchgear and Basic Relaying Protection

Standard 4.16 kv, 250 Mva, metal clad switchgear will be used for the two main auxiliary busses. The impedance of the transformer and secondary cables will limit the fault duty to the rating of the breakers. The maximum fault has been calculated as follows:

MOMENTARY FAULT AT 1/2 CYCLE

	a-c	d-c
Transformer	27,400 amps	31,800 amps
Motors	8,100	14,600
	35,500	46,400

TOTAL ASYMMETRICAL FAULT

$$\sqrt{35{,}500^2 + 46{,}400^2} = 58{,}500 \text{ amps}$$

INTERRUPTING FAULT AT 4 CYCLES

	a-c	d-c
Transformer	27,400	8,100
Motors	400	3,400
	27,800	11,500

TOTAL ASYMMETRICAL FAULT

$$\sqrt{27{,}800^2 + 11{,}500^2} = 27{,}800 \text{ amps}$$

The 250 Mva breakers are rated 60,000 amps momentary and 35,000 amps interrupting. The switchgear will be in an isolated room with concrete floors above and below. No pipes will cross the switchgear and the room incoming air will be filtered. All power and control cables will enter the switchgear from below. This arrangement will provide a dustless and dripless environment for the switchgear, thus providing greater reliability.

Previous 4160 v systems have been solidly grounded. This practice has been changed for Trenton Channel No. 9 to a resistor grounded system which limits the ground current to 600 amps. Instantaneous sensitive ground relays supplied by toroidal CT's will be furnished on each feeder. Since most faults on 4160 v systems originate as ground faults, this system will greatly reduce the damage on ground faults and limit the fault from spreading to phase-to-phase or to 3-phase faults.

Feeder circuit overcurrent protection will be provided by overcurrent and instantaneous relays in two phases, with remote ammeters provided in the third phase. On motor circuits, the overcurrent relay pickup will be 175 per cent of motor full load current. An instan-

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taneous current relay will be provided for alarm indication on motor circuits, with pickup at 120 per cent of motor full load current. The instantaneous alarm relay will provide many advantages over thermal relays in that it will provide advance warning, will be easier to test and adjust, and will be checked on each motor start.

Control, Let Down and Essential Power

With the single auxiliary transformer supplying the main auxiliaries for the unit, the need remains for some small amount of power for control, let down and essential functions.

Control power is required to operate switchgear, unit protective systems, annunciators, sequence events recorders, fire sprinkler systems, etc. This power is furnished by a unit battery. The battery will be a 130 v lead-calcium type sized for eight hour duty.

Let down power is required to protect the unit for a complete loss of the a-c system. This power will be provided from the existing plant d-c bus at 240 v., and will feed emergency bearing oil pumps for the main turbine generator and the two boiler-feed pump turbines. The plant d-c bus serves the emergency oil pumps of the existing eight units at the plant and also the boiler and turbine auxiliaries of the original six units. House generators provide power to the d-c bus, thus providing independent protection to the emergency motors of all units in the plant.

Essential power is provided at 480 v with two sources and an automatic throwover. The two sources are necessary to maintain power during maintenance work on the auxiliary transformer. The two sources are from the unit transformer, and from the existing plant. With two sources, an automatic throwover was easily added and other desirable a-c loads fed from this bus. The following loads are served from the essential bus:

1. Maintenance

   a. 30% of welding circuits
   b. 30% of plant lighting
   c. Coal handling for units 7, 8 & 9
   d. Elevator

2. Essential

   a. Boiler air heaters
   b. Boiler electronic control
   c. Control battery charger
   d. Communications
   e. Clock feeds
   f. Excitation bias supply
   g. Generator stator cooling pumps
   h. Mtg electrohydraulic control pump
   i. Mtg turning gear motors
   j. Mtg hydrogen vacuum pump
   k. Mtg hydrogen seal oil pump
   l. Mtg auxiliary suction oil pump
   m. Bfp main oil pumps
   n. Bfp turning gear motors
   o. Bfp oil dump valves
   p. Booster pump, fire protection

Additional protection is provided to many of the services on the essential bus by duplicate motors with feeds from other 480 v busses. Also, a small automatic start Diesel-generator is provided as a standby source for communications; an emergency battery charger is provided from the plant d-c bus; and a second unit source is provided for the boiler control.

Other Electrical Features

Several other electrical features of Unit No. 9 should be mentioned where past practice has been modified or even considerably changed.

The turbine generator is a tandem-compound, four-flow machine, thus departing from the cross-compound machine installed with the last nine units on The Detroit Edison Company system. The generator will have a water-cooled stator and hydrogen-cooled rotor operating at a maximum pressure of 45 psig. The shaft-driven exciter will include an a-c generator and silicon rectifiers with an amplidyne voltage regulator. No spare exciter will be provided, but a spare bank of silicon rectifiers will be provided. An electrohydraulic governor will control the turbine. A programmed automatic startup control system has been added to the turbine-generator electrohydraulic control system.

The generator bus is rated ~~18,000~~ 16,000 amperes at 22,000 volts. The bus will be welded aluminum and forced-air cooled.

All 4160 v power cables will have butyl and neoprene insulation and will be run in ladder type trays. The auxiliary transformer cables will be made up of 2-1500 Mcm cables per phase and will be transposed to balance the impedance and eliminate negative sequence currents. Three conductor, triplexed, non shielded cables will be used for feeders to motors and transformers.

All 600 v power cables for motor circuits will also have butyl and neoprene insulation and will be run in ladder type trays. Multi-conductor control cables will be PEPVC type with 15 mils of polyethelyne and 30 mils of polyvinyl chloride. Cables entering switchgear, motor control centers and control boards will enter from below to protect the electrical equipment from dripping water.

The boiler control equipment will be completely electric with all burner and boiler control functions controlled from the unit control room. Sequence events recorders and printers will provide vital information about off-normal conditions and emergency situations.

CONCLUSIONS

The design of the auxiliary electrical system for Trenton Channel No. 9 is based on a major change in the philosophy in the design of electrical supply to the auxiliaries. The basic premise of this philosophy is that no damage will result from the loss of the unit's major electrical sources, thus leading to the conclusion that backup sources of power are not required to protect the unit. One transformer to feed the unit's auxiliaries which is connected to the generator high voltage bus satisfies this conclusion.

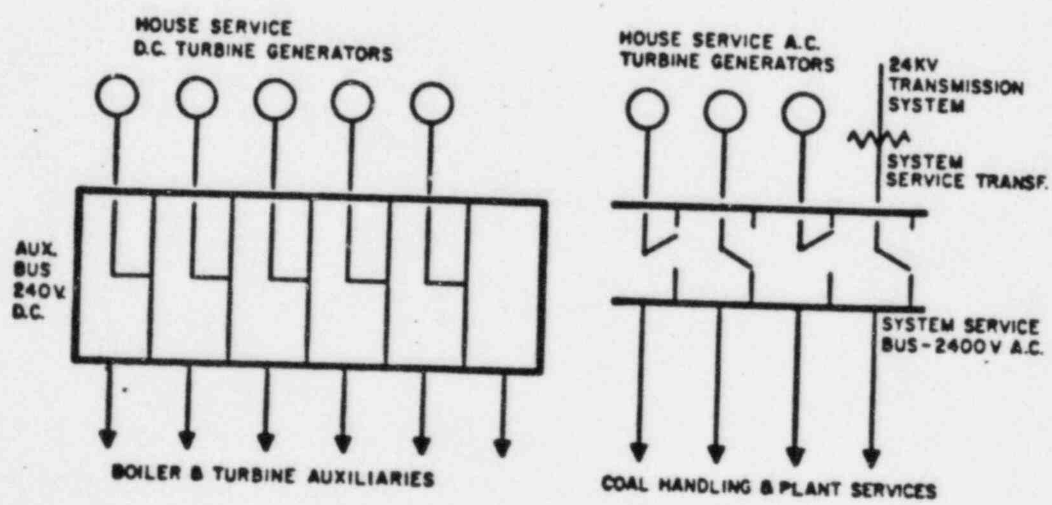
Based on these conclusions, the major auxiliary electrical system for Trenton Channel No. 9 will include one transformer supplying the main auxiliaries of the unit. The transformer will be connected to the unit's high voltage bus, thus providing an exceedingly simple system. Major auxiliary bus transfers and auto-throwovers have been eliminated. Power for smaller essential services and for maintenance work when the transformer is down for service is provided by an essential 480 v bus with dual feeds from the unit transformer and the existing plant.

The Detroit Edison Company considers the engineering of Trenton Channel No. 9 auxiliary system to be a forward step in the design of power plant auxiliary systems.

TABLE I

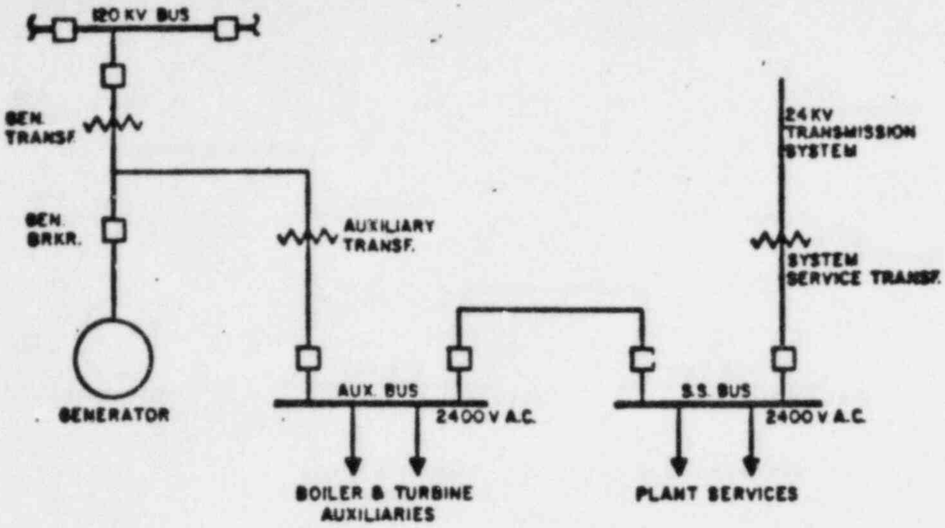
Trenton Channel No. 9
Auxiliary Transformer Loads

East Auxiliary Bus		
3	Condenser Circulating Pumps	500 hp
1	Induced Draft Fan	3500 hp
1	Forced Draft Fan	1750 hp
8	Coal Mills	800 hp
1	Coal Handling Feeder	
	Conveyor Motor	900 hp
	Transformer	750 kva
	Transformer	500 kva
1	480 v feeder	
	Precipitator Transformer	1000 kva
	Standby Transformer	1500 kva
West Auxiliary Bus		
2	General Service Pumps	400 hp
4	Boiler Circulating Pumps	700 hp
1	Induced Draft Fan	3500 hp
1	Forced Draft Fan	1750 hp
2	480 v Feeders	
	Precipitator Transformer	1000 kva
	Bus 1 Transformer	1500 kva
	Bus 2 Transformer	1500 kva
2	Heater Drains Pumps	450 hp
3	Condenser Condensate Pumps	250 hp
1	Station Air Compressor	350 hp



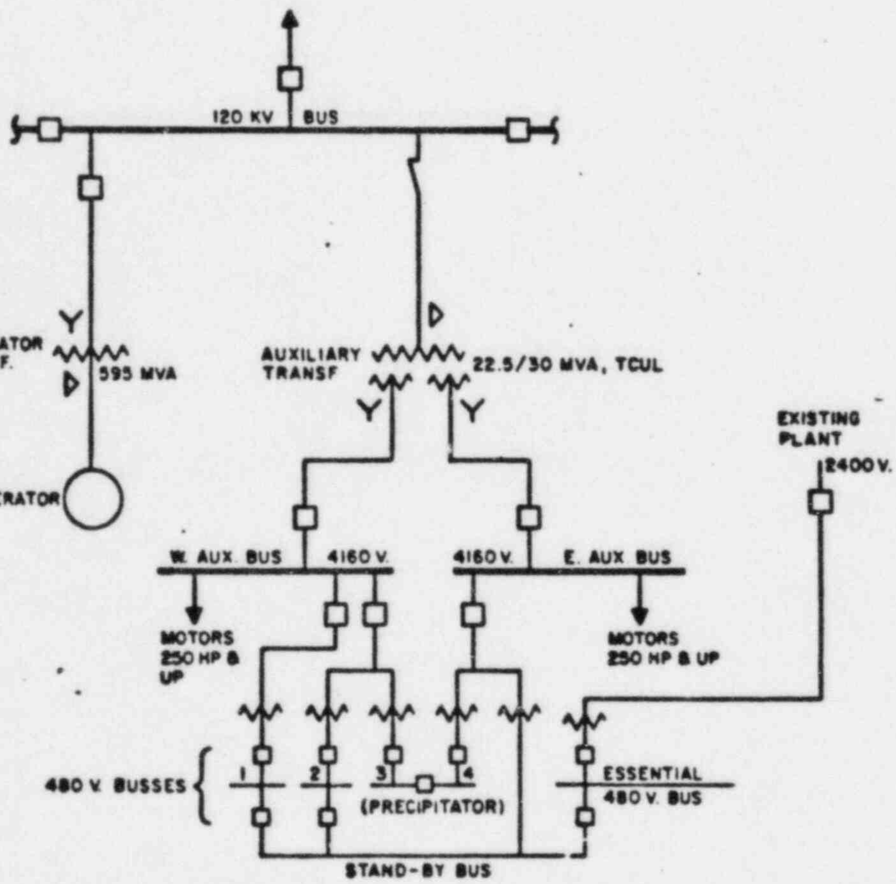
TRENTON CHANNEL POWER PLANT AUXILIARY SYSTEM
ORIGINAL PLANT - MID 1920's

FIG. 1



TRENTON CHANNEL POWER PLANT AUXILIARY SYSTEM
FIRST PLANT EXPANSION-EARLY 1950

FIG. 2



TRENTON CHANNEL POWER PLANT AUXILIARY SYSTEM
SECOND PLANT EXPANSION-UNIT NO. 9, 1967

FIG. 3