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COMMISSIONING A MAJOR RETRO FIT IN AN EXISTING NUCLEAR POWER STATION

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INTRODUCTION

The Low Pressure Emergency Core Injection (ECI) System at Bruce NGS 'A' is being replaced by a new high pressure system. The new system is similar to that being installed in the Bruce NGS 'B' plant which is scheduled to start up later this year. The new system at Bruce NGS 'A' will be connected to Unit 4 in April 1984, and the other units will be converted at six monthly intervals. Commissioning activities are well under way and it is apparent that there are significant differences between commissioning a major retro fit in an existing station, compared with commissioning a whole new project.

ECI SYSTEM DESCRIPTION

Figure 1 shows a simplified flowsheet of the existing system. This system injects water automatically into any of the four reactors in the event of a loss-of-coolant accident. This automatic phase is followed by manual start-up of the Recovery System when the water level has built up in the recovery sump.

Figure 2 shows a simplified flowsheet for the new system. This system has three fully automatic phases:

1. Injection of water at high pressure from the accumulator tanks,
2. Injection of water from the grade level tank via the recovery pumps,
3. Recirculation from the recovery sump via the pumps and heat exchangers.

The equipment up to and including the common supply header is common to all four units.

A loss-of-coolant accident in any unit will trigger the following actions:

1. Opening of gas accumulator tanks outlet valves (valves A in figure 2),
2. Opening of the D_2O isolation valves (Valves B) and the H_2O injection valves (valves C) in the faulted unit,
3. Opening of boiler safety valves (not shown in figure 2) in the faulted unit. This causes a crash cooldown of the boilers and enhances the heat removal from the primary coolant.

The above actions are required for Phase 1, ie, injection from the accumulator water tanks. At the same time, the following actions are triggered to prepare for Phase 2:

4. Grade tank outlet valves (valves D) open,
5. Two of the recovery pumps start up.

Phase 1 ends when low level is detected in the accumulator water tanks. This triggers the closure of the tank outlet valves (valves E). The pressure in the common header now falls to the discharge pressure of the recovery pumps. At this point the check valves F open, starting Phase 2, ie, injection from the grade tank.

This phase ends on the detection of high level in the recovery sump or low level in the grade tank. This triggers the opening of the recovery sump valves (valves G), closing of the grade tank valves (valves D), and closing of the heat exchanger bypass valves (valves H). The system is now operating in the third phase with water from the break being collected in the sump and re-injected through the heat exchangers.

EQUIPMENT LAYOUT

Figure 3 shows the layout used at Bruce NGS 'A'. The new gas and water tanks are housed in new structures on the north side of the plant. The recovery sump, heat exchangers, and pumps are in a new structure called the East Service Area. The common instrumentation is housed in a new room within the plant, room R3-332. All of this equipment, except for its service systems, can be constructed and commissioned as in a new project.

The new common header on the north side of the reactor, is constructed immediately underneath the existing header and there were many interferences with existing equipment such as piping connections from the existing header, and overhead cable trays.

In each unit area equipment has to be relocated to clear the way for constructing the new unit header and check valves. This area is congested and contains sensitive equipment such as instrumentation for Shutdown System No. 2 and existing ECI.

EQUIPMENT INSTALLATION.

All of the common equipment is new and can operate in parallel with the common equipment of the existing system. The unit equipment inside containment, ie, the D_2O isolation valves, will be re-used in the new system. New equipment can be installed at power up to the air gap which is the D_2O/H_2O interface.

A unit can be converted from the old to the new system, when shutdown, by cutting the four injection lines outside containment and then installing the four injection check valves and the unit injection header. The existing test valve, which is a quick-acting hydraulically operated valve, will be used as a new H_2O injection valve in a subsequent unit.

ORGANIZATION

The Commissioning unit in Bruce NGS 'A' has the normal responsibilities associated with commissioning the ECI and co-ordinating the commissioning of its service systems. In addition, they are responsible for the removal of interferences and for co-ordinating the connections to existing systems.

The designers organize the engineering packages into two types viz, new work and ECN (engineering change notice) work. New work does not require changes to existing systems and is assigned directly to the site Construction group. ECN work is assigned to the Commissioning Unit who normally retain responsibility for the final tie-in connections, and assign the balance to Construction.

ECN work is assessed jointly by the Commissioning and Construction groups to identify interferences, define the scope of Construction involvement and decide how much work can be done at power.

New work is assessed by Construction to identify interferences with existing systems.

The resolution of interferences requires either the re-design of new equipment or the relocation of existing equipment; and is a team effort involving Design, Construction and Commissioning groups. In those cases where relocation of equipment is required, the Commissioning group is responsible for co-ordinating the work.

COMMISSIONING OBJECTIVES

The objectives of a Commissioning group are to confirm design adequacy, and installation procedures, and to maintain cost and schedule requirements. In the case of the ECI System at Bruce NGS 'A' there is the additional objective of minimizing the loss of electrical production.

This loss can arise because of:

1. Deratings or shutdowns due to relocating existing equipment, or making connections to existing systems,

2. Shutdown time required to install and commission the new ECI System on each reactor.

These two factors often conflict with each other. There is a strong motivation to install and commission as much equipment as possible at power. However, this may require the relocation of sensitive equipment with the resulting potential to cause an unplanned shutdown. If it is possible, advantage should be taken of any planned maintenance shutdown, prior to the tie-in shutdown, to perform such sensitive work. Since the maintenance shutdowns at Bruce NGS 'A' occur at two yearly intervals, considerable lead time is required to identify such sensitive work. An example of such work already performed at Bruce NGS 'A' is the relocation of equipment within the existing ECI panel in the main control room, and the drilling of a new cable access hole in the floor under this panel.

The system had been designed so as to maximize the amount of equipment that could be installed and commissioned at power.

The common system involves mostly new work in new locations, and the common header on the north side of the reactors is the only component that has proved troublesome due to proximity to existing equipment. There have been no major problems in connecting the common services to the existing station systems. It is possible, therefore, to install and commission all of the common system with no impact on station production.

This contrasts with the unit system where all the equipment must be installed in operational areas including existing instrument rooms and the main control room. The designers chose locations which permitted as much equipment as possible to be installed at power. This still left key items such as the control room panel and crash cooldown panels which could not be installed until the unit was shutdown to convert from the existing to the new ECI System. These panels were designed in modular form and were pre-wired to minimize installation time. However, since these key items could not be pre-installed, the instrument and logic loops could not be energized at power and virtually no commissioning was envisaged on the unit system prior to the shutdown.

This situation affected other design decisions. For example, it had been decided to re-use existing control power supplies and to relocate the existing test valve in a H_2O injection valve position during the shutdown since these actions did not appear to affect the duration of the shutdown.

When commissioning procedures were prepared, it was found that commissioning could add more than three weeks to the duration of the shutdown. This would be in addition to any time required to rectify defects found in the commissioning process. It was then decided to have a re-assessment by Design, Construction and Commissioning groups, with a view to find ways to install and commission equipment prior to the shutdown.

The critical area was identified as the main control room panel. It was clear that the new panel modules could not be mounted permanently until the existing panel could be taken out of service. It was decided, however, that the new panel modules could be mounted on a temporary frame behind the existing panel.

The panel layout was modified to intersperse new terminal strips between the existing equipment to allow the new field devices to be interconnected with the new modules without affecting continued operation of the existing ECI System. This solution was made possible by relocating existing equipment and by drilling new cable entry holes. It was fortunate that the solution was identified in time to allow its implementation during a maintenance outage on Unit 4.

Attention was then focussed on arranging pre-installation of other parts of the system. Existing crash cooldown instrumentation was relocated so as to permit installation of the new equipment. Some instrument transmitters which could not be mounted in their permanent locations were assigned temporary mountings with flexible connections. Also, small fill and vent valves in the area of the unit header were assigned new locations.

With the discovery that all key unit equipment could be pre-installed it was possible to revise some earlier design decisions. The provision of new control power supplies was now justified as they permitted the new system to be energized and commissioned independently of the existing system. Also, it was decided to redeploy the H_2O injection valves by using two new valves in the first two units and reusing the existing test valves in the last two units.

The new instrument transmitters which detect and confirm a loss-of-coolant cannot be supplied with their process signals until the shutdown.

However, each transmitter is supplied with a test signal so that it is possible to test and commission each instrument and logic loop.

The result of this exercise is that it has been found possible to commission at power all equipment except the four new header check valves. In the case of the crash cooldown the functions can be checked as far as the solenoid valves which supply instrument air to operate the boiler safety valves. In the case of the D2O isolation valves the control logic can be fully checked but the final connections and function testing must be done at shutdown. All other equipment is new and can be fully checked through to the end devices before the shutdown.

CO-ORDINATION OF CONSTRUCTION

In the new areas, such as the Accumulator Building, construction activities are similar to those on any new project. However, work within the operating island is complicated by the following considerations:

- Movement of personnel and equipment is complicated by security, and radiation protection requirements,
- Work authorizations have to be obtained from Operations personnel,
- Construction work conflicts with the normal testing and operation of equipment.

Some of these problems can be alleviated by dedicating Operations' staff to work closely with Construction on the ECI System. At present, one operator works full time on the ECI System and the complement is being increased to two operators in the near future. As well as performing commissioning checks, they streamline work authorizations and co-ordinate Construction activities with operational requirements.

Six Control Maintenance Technicians from Operations are assigned to work part-time with the Construction Engineering group. They perform Construction pre-turnover inspections as well as pre-operational tests on behalf of Operations.

Two Mechanical Maintainers have a similar role in mechanical pre-operational and commissioning checks.

Commissioning procedures and work plans are prepared and co-ordinated by three commissioning engineers. Along with the previously mentioned personnel they form the commissioning team.

The prime purpose of these arrangements is to ensure close work control but some other advantages have followed. It has been possible to avoid duplication of effort by integrating some Construction inspections with Operations' pre-operational checks and to facilitate the transfer of knowledge and expertise between the groups. It is possible to organize the turnover of equipment in small packages rather than in large blocks to allow work to be scheduled more uniformly, although this does result in extra documentation.

CONCLUSION

The major implication of retro fitting a large system in an existing power station is the potential impact on electrical production of the station. To minimize this impact, it is essential to have a team approach involving Commissioning personnel, Design and Construction groups to resolve interferences, relocate equipment and organize the work to permit at-power installation and testing. This team approach should be started at an early phase of design so as to minimize the expense of design changes and identify sensitive work which should be done during planned station outages.

During installation, close cooperation is required between Construction and Commissioning groups to expedite work while minimizing the possibility of causing a derating or plant shutdown. This co-operation can result in avoiding duplication of effort by integrating inspection activities. Also, it is possible to have equipment turned over to Operations in smaller packages than is customary on a new project.

ACKNOWLEDGEMENT

Throughout this paper, there is repeated reference to the need for close and flexible cooperation between Commissioning personnel and the various Design and Construction groups. These references are based on early commissioning experience with the Bruce NGS 'A' high pressure ECI System. The co-operation of the Atomic Energy of Canada Ltd. and Ontario Hydro Design groups, and Ontario Hydro Generation Projects Division has been invaluable in the commissioning activities. Their contribution is gratefully acknowledged.

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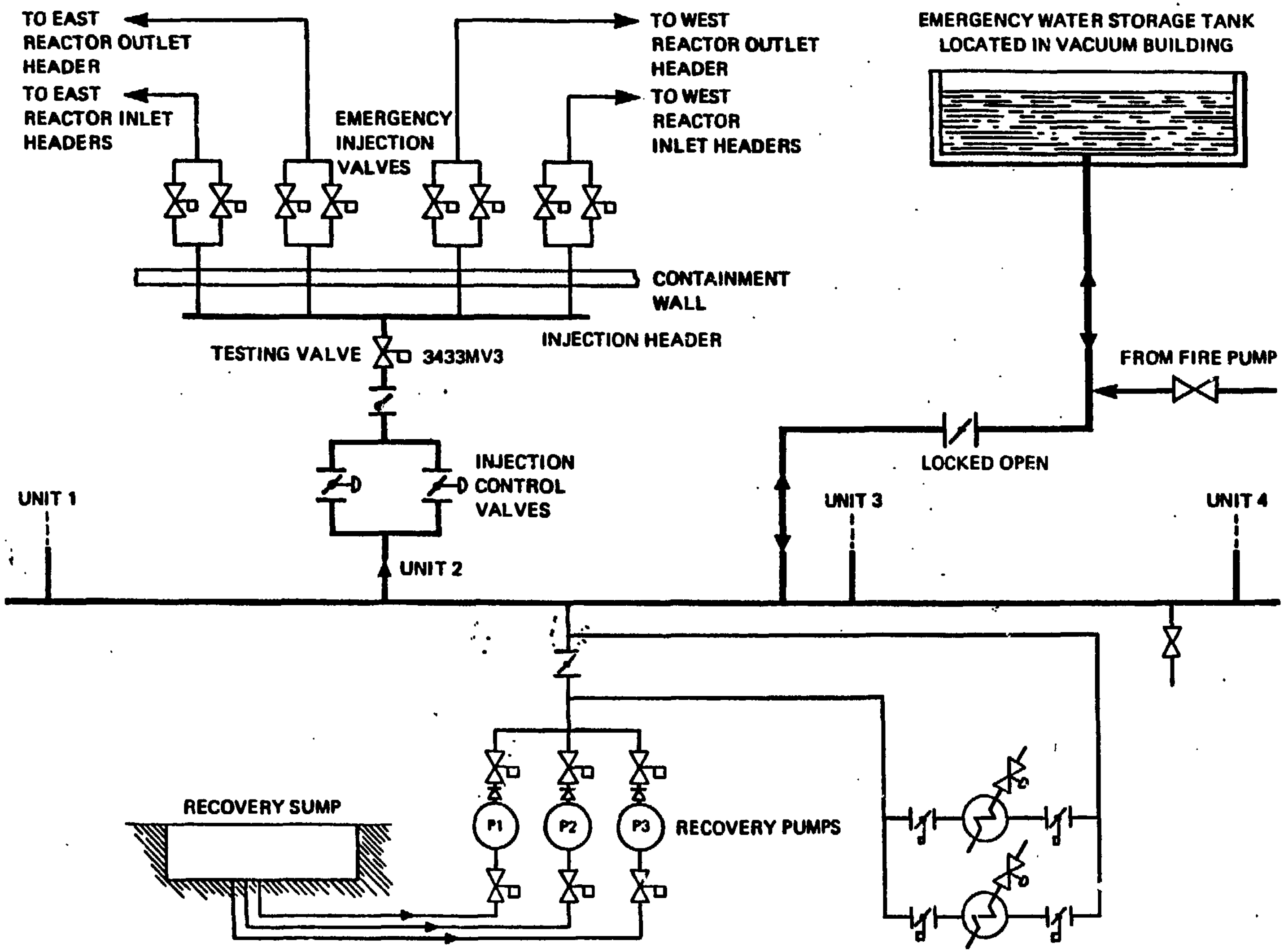

FIGURE 1 EMERGENCY CORE COOLING SYSTEM

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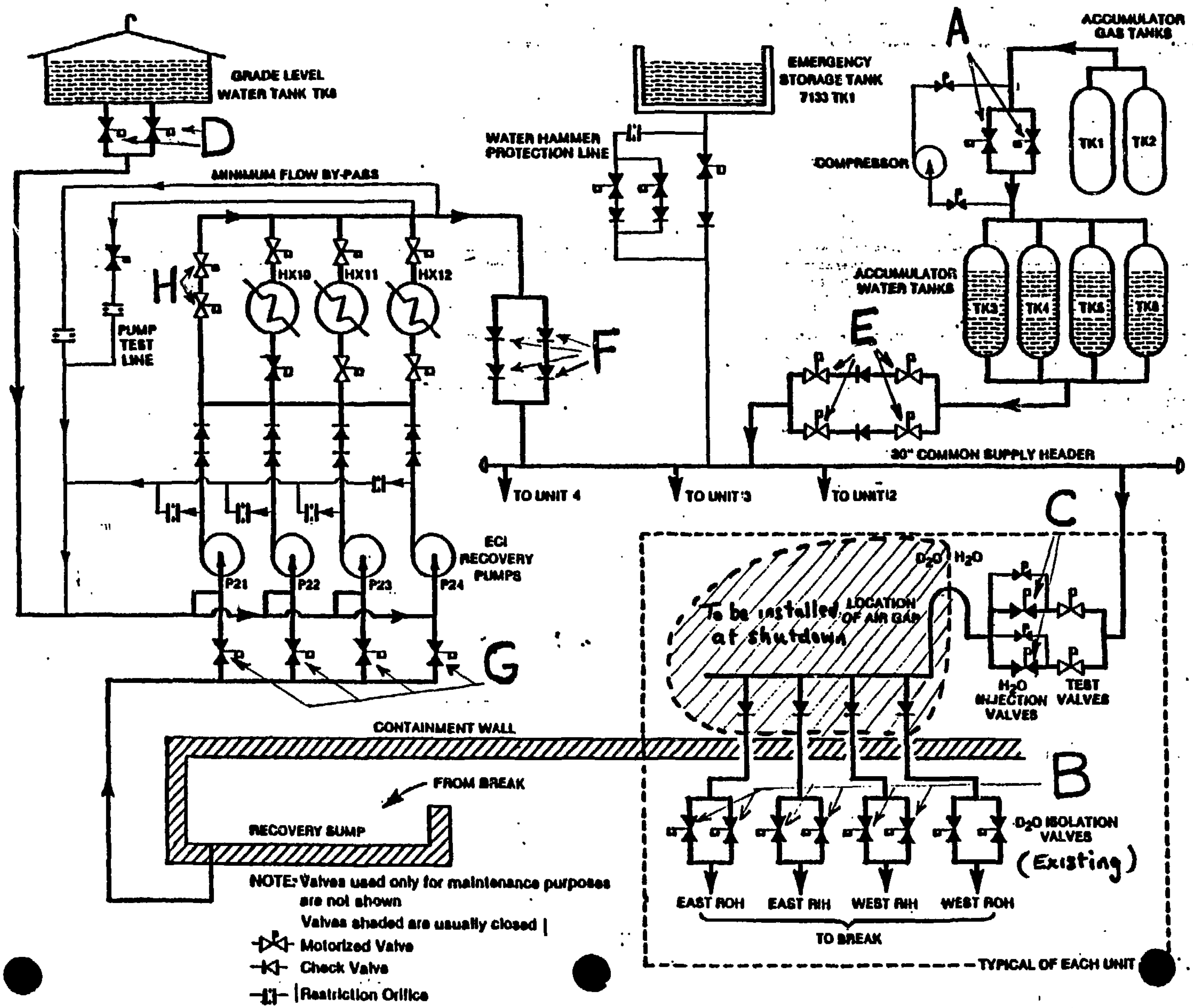

FIGURE 2 EMERGENCY COOLANT INJECTION SYSTEM SIMPLIFIED FLOWSHEET

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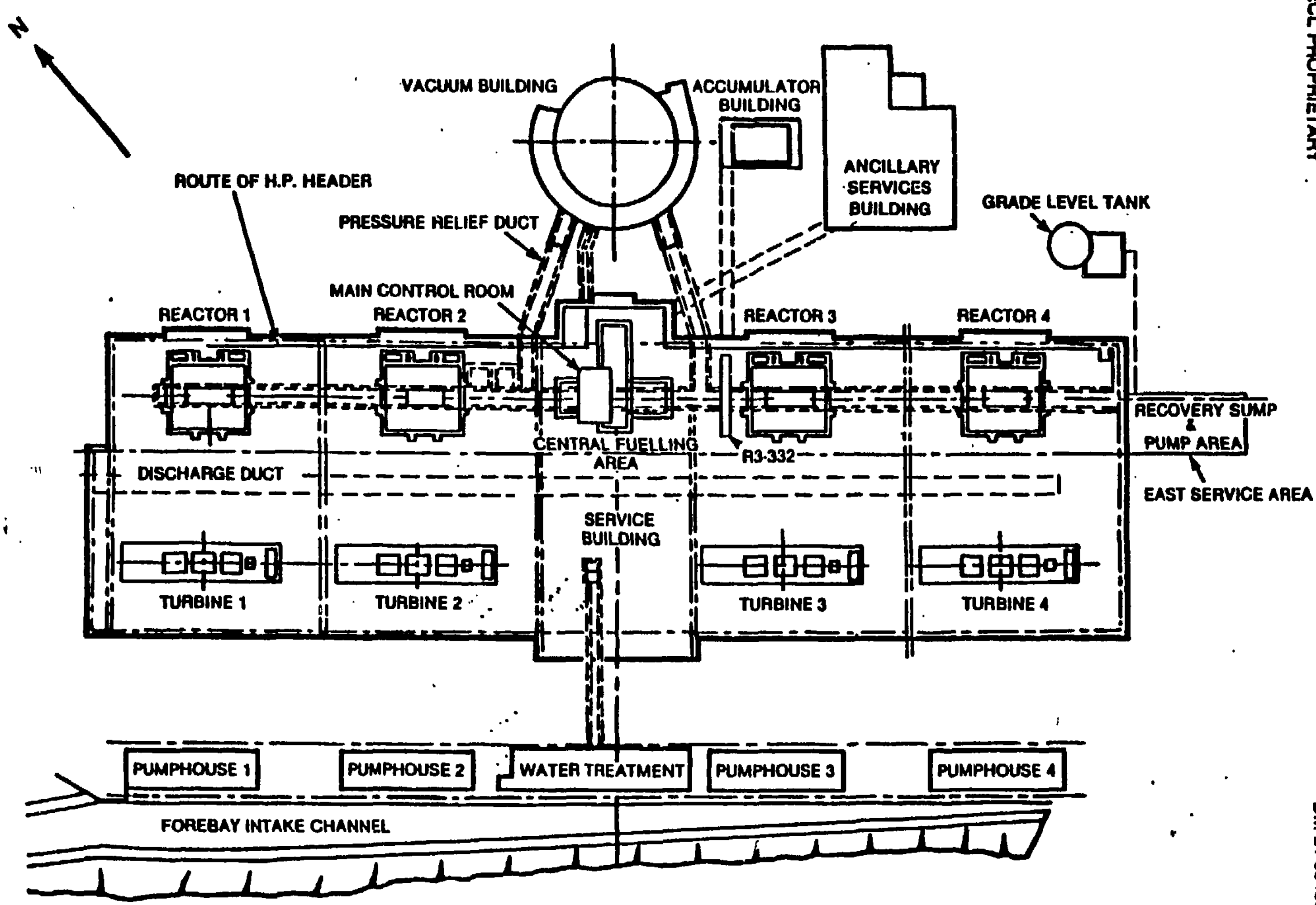

FIGURE 3 BRUCE "A" GENERATING STATION SITE PLAN

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