NORTHERN STATES POWER COMPANY
MONTICELLO NUCLEAR GENERATING PLANT

IMPLEMENTATION OF HYDROGEN WATER CHEMISTRY

April 10, 1987

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I. INTRODUCTION

A. Purpose

Northern States Power Company has elected to reduce the potential for Intergranular Stress Corrosion Cracking (IGSCC) by implementing Hydrogen Water Chemistry (HWC). This report describes the HWC system to be installed at Monticello and provides other information related to this process.

B. Scope

The scope of work to be performed includes the installation of hydrogen piping, oxygen piping, a cryogenic hydrogen supply, a cryogenic oxygen supply, gas injection provisions, instrumentation, and controls. The project will include a crack arrest verification program and a program to reduce radiation exposures to as-low-as reasonably-achievable (ALARA).

C. Background

The recirculating coolant in Boiling Water Reactors (BWRs) is high purity neutral pH water containing radiolytically produced dissolved oxygen. This level of dissolved oxygen is sufficient to provide the electrochemical driving force needed to promote IGSCC of sensitized austenitic stainless steel piping and similar structural components if a sensitized microstructure and a tensile stress above the yield stress are also present.

Monticello has replaced the reactor recirculation system piping with a low carbon nuclear grade material to eliminate sensitized material and has performed Induction Heat Stress Improvement (IHSI) on welds to eliminate tensile stress. The installation of a HWC system would further reduce the probability of IGSCC in piping and improve the resistance to IGSCC in vessel internal components by reducing the electrochemical driving force.

The HWC technique consists of reducing the coolant dissolved oxygen level from approximately 200 ppb to that level which, in combination with high water quality, has been shown to result in IGSCC immunity. The reduction in coolant oxygen is accomplished by the addition of hydrogen. Conductivity is maintained sufficiently low by good water quality operational practices. The feasibility of suppressing oxygen in this manner has been demonstrated in several operating Boiling Water Reactors (BWR's).

The excess hydrogen in the reactor water is removed by the condenser air removal system and is processed through the off-gas system. To minimize the potential for hydrogen explosions in the off-gas system, oxygen is injected into the off-gas stream upstream of the off-gas recombiners where the hydrogen is removed. Figure 1 is a simplified diagram showing the hydrogen water chemistry gaseous addition injection points.

I. INTRODUCTION (Continued)

D. Conformance With EPRI Guidelines

The Monticello installation will conform with all requirements (shall statements) of the "Guidelines for Permanent BWR Hydrogen Water Chemistry Installation", 1987 Revision (Reference 1) with the following exceptions:

1. Section 2.3.2.1, Injection Point Considerations - Oxygen is being injected in the common off-gas line just before the recombiner. The plant has not experienced significant problems with off-gas fires to date. Oxygen concentration will be controlled to be similar to existing concentrations upstream of the recombiner. If problems are encountered corrective action will be taken as needed.

2. Section 2.3.2.2, Codes and Standards - The oxygen and hydrogen piping will meet the requirements of 29CFR1910.104 and 29CFR1910.13 respectively except the pipe will conform to ANSI B31.1, 1977 Edition with Addenda through Winter 1978 with impact testing to $-50^{o}F$. This is a more conservative design than ANSI B31.3, 1966 Edition as required by the code of federal regulations.

3. Table 2-1, Recommended Trips of the Hydrogen Addition System -

   a) The system will trip at a setpoint that is greater than 20% power based on main steam flow. This is conservative per Section 8.2.2.

   b) There is no system trip on reactor scram. The system will trip on low steam flow at a setpoint greater than 20% power. This will provide equivalent protection.

4. Table 2-2, Hydrogen Addition System Instrumentation and Controls -

   a) No high alarm will be provided in recirc water dissolved oxygen. This parameter is indicated and routinely recorded. Any problems will be detected by plant personnel.

   b) The hydrogen storage tank will not be provided with a vacuum gauge for continuous indication of vacuum in tank annular space. A readout connection will be provided. Vacuum will be checked during routine system inspections performed every 6 months. This is in compliance with vendor recommendations.

   c) The oxygen storage tank will not be provide with a gauge for continuous indication of vacuum on the tank annular space. A readout connection will be provided. Vacuum will be check during routine system inspections performed on an annual basis. This is in compliance with vendor recommendations.

I. INTRODUCTION (Continued)

D. Conformance With EPRI Guidelines (Continued)

d) The hydrogen pump will also trip on high discharge pressure.

5. Section 3.1.2.1, Hydrogen Storage Vessels - Code Case 1205 has been incorporated into Appendix 14 of ASME Section VIII Code. Therefore, the code requirements of $-40^{\circ}F$ for service temperature shall be met rather than $-20^{\circ}F$ as specified in Code Case 1205

6. Section 3.4.2.3, Vaporization - The oxygen vaporizer will be a single unit (not parallel units). Capacity will be adequate for plant flow and ambient conditions.

7. Section 3.4.4, Oxygen Cleaning - All piping and equipment contacting oxygen is cleaned in accordance with CGA4.1 prior to installation. Each connection is inspected at fitup and all open ends are covered to maintain cleanliness. Therefore, it is not anticipated that cleaning will be required after construction.

8. Section 6.4, Identification - Pipe is color coded in accordance with ANSI Standard A13.1 and not ANSI Z35.1. ANSI Z35.1 defines criteria for signs which will be used to mark buried pipe routing.

II. DESIGN DESCRIPTION

A. Design Criteria

The piping and instrumentation diagram for the hydrogen water chemistry system is shown in Figure 2. The system is divided into hydrogen injection, oxygen injection, instrumentation and control, hydrogen supply, and oxygen supply subsystems.

The hydrogen water chemistry system is not safety related. Equipment and components are not class IE or environmentally qualified. The hydrogen and oxygen piping will be designed and supported to Seismic Category II requirements. Where this piping is routed in the proximity to safety-related equipment, the requirements of Seismic Category I shall be applied and the hangers will be classified as II over I.

1. Hydrogen Injection Subsystem

The hydrogen injection subsystem includes all piping, flow control, flow measuring, and all other instrumentation and controls to ensure safe, reliable operation. Equipment will be sized to maintain an injection rate of 6-40 standard cubic feet per minute of hydrogen. The flow rate at full power operating conditions is expected to be 35 scfm.

Hydrogen injection connections are installed in the feedwater pump suction cavity drains. The pump manufacturer, Transamerica Delaval, Inc., has stated that hydrogen injection will not degrade pump reliability or performance. This point was selected to ensure that gas will be dissolved rapidly and completely with no adverse effects on pumps, condensate treatment system, instruments, or feedwater flow uniformity. Hydrogen will be heated prior to injection into the pump to insure no thermal fatigue condition could occur.

II. DESIGN DESCRIPTION

A. Design Criteria (Continued)

1. Hydrogen Injection Subsystem (Continued)

Piping attached to the pumps upstream of double isolation valves on each pump will be considered as part of the feedwater system. The remaining injection piping is included in the HWC system.

Design temperature and pressure will be -40°F and 600 psig, respectively with operating conditions of ambient temperature and 500 psig.

Hydrogen delivery pipe from the supply to the feedwater pump connections will be carbon steel (A333 Grade 6), and impact tested to -50°F as required by the material specification. Weld material and weld procedures will also be qualified to -50°F impact testing. Outdoor piping will be 2-inch coated and wrapped and buried in a trench. Fabrication and testing will be in accordance with ANSI B31.1, 1977 through Winter 1978 Addenda. Soil samples will be taken to assure proper soil conditions exist to preclude frost heave loads. Use of ANSI B31.1 with material and weld properties qualified for use at -50°F is more conservative then use of ANSI B31.3.

An excess flow device will be installed at the hydrogen supply station (not shown on Figure 2) and before entering the turbine building to provide protection against pipe breaks. Potential leak sources in the turbine building such as flanged connections or valves will be controlled by installing this equipment in a central location. Hydrogen monitors will be placed in strategic locations to monitor for hydrogen leaks and will trip hydrogen injection at a hydrogen concentration below the flammability limit. Since the area hydrogen concentration is not allowed to reach combustible concentrations, the electrical installation need not be explosion proof. The flow measured near the hydrogen supply will be compared with the sum of the flow signals into the individual feedwater pumps and a preselected deviation will initiate an alarm to alert operators of the possibility of a leak insufficient to actuate the excess flow devices or hydrogen monitors.

Individual pump injection lines will contain double check valves to prevent feedwater from entering the hydrogen line. Automatic isolating flow control valves will be provided in each injection line to prevent hydrogen injection into an inactive pump.

Purge connections will be provided near the feedwater pumps with a key locked hand switch to allow purging nitrogen through the flow control valves when maintenance is required and before hydrogen is introduced into the line.

II. DESIGN DESCRIPTION (Continued)

A. Design Criteria (Continued)

2. Oxygen Injection Subsystem

The oxygen injection subsystem injects oxygen into the off-gas system to ensure that all excess hydrogen in the off-gas stream is recombined. It includes all necessary flow control and flow measurement equipment to maintain oxygen flow sufficient to recombine with all the hydrogen in the off-gas stream.

The outside piping will be 1-inch coated and wrapped for corrosion protection and buried in a trench. The design temperature and pressure is -40°F and 100 psig respectively with operating conditions of -40° to 104°F and 35-75 psig. The oxygen flow rate is half the hydrogen flow rate (expected to be 18 scfm during normal full power operation).

The oxygen addition subsystem includes three standard oxygen bottles which act as an emergency backup supply in the event that the main supply is interrupted. This quantity of oxygen is sufficient to recombine the hydrogen remaining in the system following a hydrogen system isolation. This emergency supply system is equipped with a relief valve in the recombiner building which discharges to the atmosphere above the recombiner building roof.

3. Instrumentation and Control

The hydrogen and oxygen injection will be controlled from a control panel located in the northeast corner of the turbine building on the 931 foot elevation.

Hydrogen monitors will be placed in areas selected on the basis of air movement to detect possible hydrogen leakage from valves or flanges. These monitors will provide a hydrogen system trip prior to the accumulation of any combustible concentrations of hydrogen.

a. Control Strategy

Microprocessor-based analog controllers and programmable logic controllers have been selected to control the injection of hydrogen and oxygen gases. These types of controllers will provide the flexibility for future changes if needed. The logic and control system configuration are briefly described below.

II. DESIGN DESCRIPTION (Continued)

A. Design Criteria (Continued)

3. Instrumentation and Control Continued)

b. Control Logic (Continued)

Hydrogen injection on a system level will be automatically controlled by plant load (main steam flow) and manually controllable with a control switch. Injection into the reactor feed pumps is interlocked with individual pump breaker position and recirculation valve position. The hydrogen injection system is automatically shutdown when any of the following conditions exist:

1. High Hydrogen Flow
2. High Main Steam Flow
3. Area Monitor High Hydrogen Concentration
4. Low Oxygen Pressure
5. Offgas System Recombiner Train Trip
6. Low Oxygen Concentration in Offgas
7. Manual Trip from Control Room
8. Manual Trip from Remore Control Panel

A single trouble alarm will annunciate in the control room simultaneous with an alarm on the local HWC panel. The following conditions provide annunciation on the local panel:

1. Hydrogen System Trip
2. Hydrogen Flow High
3. Area Hydrogen Gas Detector High
4. Oxygen Primary Control Failure
5. Oxygen Flow High
6. Recombiner Outlet High Oxygen Concentration
7. Hydrogen Flow Low
8. Area Hydrogen Gas Detector Trouble
9. Oxygen Injection Manual Override
10. Oxygen Flow Low
11. Recombiner Outlet Low Oxygen Concentration
12. Hydrogen Supply Trouble
13. Hydrogen Differential Flow High
14. Oxygen Supply Trouble
15. Oxygen Supply Pressure Low

c. Hydrogen Injection

Hydrogen gas will be injected into the reactor feed pumps at a flowrate which is determined by the plant load (main steam flow). The hydrogen flow requirement as a function of plant load is non-linear and will be empirically determined during plant testing. This relationship will be used to set the function generator within the H_2 flow controllers.

II. DESIGN DESCRIPTION (Continued)

A. Design Criteria (Continued)

3. Instrumentation and Control (Continued)

Hydrogen injection inhibits include feedwater pump not running and feedwater recirculation valve open. This will prevent injection into a nonrunning pump and the introduction of hydrogen rich water directly into the condenser.

d. Oxygen Injection

Redundant control systems have been provided for oxygen injection such that failure of one instrument or component would not prevent oxygen injection. The two control modes associated with oxygen injection are feedforward and cascade.

Feedforward

Similar to the hydrogen injection case, the oxygen flow requirement is a function of hydrogen flow and will be empirically obtained by tests in the plant.

Cascade

In this mode of control, the feedforward setpoint signal is arbitrarily reduced by 30% and added to the output of the oxygen concentration controller block. The oxygen concentration controller varies its output until the desired oxygen concentration at the recombiner outlet is obtained. The primary advantage of this mode of control is to provide closed-loop control of the oxygen content of the released gases and to optimize the consumption of oxygen gas.

4. Hydrogen Supply

a. Equipment Description

Liquid hydrogen has been selected as the supply source for the Monticello hydrogen water chemistry system. Since the injection pressure must overcome a range of feedwater pump suction pressures ranging from 200 psig to 400 psig, a high pressure supply using cryogenic pumps is required. A typical equipment arrangement is shown in Figure 3.

Hydrogen is stored as a cryogenic liquid at approximately minus 420°F and 100 psig in a vacuum-insulated storage tank. Liquid hydrogen storage is economical and convenient, because at normal temperature and pressure one volume of liquid hydrogen converts to approximately 845 volumes of gaseous hydrogen.

II. DESIGN DESCRIPTION (Continued)

A. Design Criteria (Continued)

4. Hydrogen Supply (Continued)

a. Equipment Description (Continued)

Cryogenic pumps connected to the storage tank automatically withdraw liquid hydrogen from the tank through a flexible vacuum-jacketed supply line designed to minimize heat leakage to the liquid being pumped. The high-pressure liquid converts to a gas as it passes through a cryogenic heat exchanger. The gaseous hydrogen is then stored in high-pressure receivers that provide surge volume and also minimize pump start-stop cycles.

When pressure in the receiver banks decreases to a predetermined level, a switch automatically starts the cryogenic pump which operates until the receivers are again fully recharged. At this time, a switch automatically stops the pump. Should the primary pump fail to operate, the stand-by pump starts and an alarm is sounded. The hydrogen storage bank is composed of ASME code gas storage vessels. Each tube will be constructed as a seamless vessel with swagged ends. Specific tube design will be based on the ASME Unfired Pressure Vessel Code, Section VIII, Division 1.

The ideal liquid tank size for supplying the estimated hydrogen requirement at fullpower on a long term basis is 9000 gallons. Therefore, tank siting has been based on a 9000 gallon liquid tank using the criteria described in the "Guidelines for Permanent BWR Hydrogen Water Chemistry Installation" (Reference 1) and "Separation Distances Recommended for Hydrogen Storage to Prevent Damage to Nuclear Power Plant Structures from Hydrogen Explosion" which is provided as Appendix B to Reference 1.

Transportable tube trailers are intended to be used for testing the HWC installation prior to the 1987 outage and to obtain sufficient input data for the programmable controllers so the system can be programmed for automatic operation following the 1987 outage. Transportable hydrogen vessels will be constructed and tested in accordance with DOT specifications 3A, 3AA, 3AX or 3AAX. Each tube bank will be equipped with a close-coupled shutoff valve. As an alternative, one safety valve per bank of tubes may be used, provided the safety valve is sized to handle the maximum relief from all tubes tied into the valve. Each tube bank will be equipped with a thermometer and a pressure gauge, as is necessary for proper filling. A tube trailer discharge stachion will be provided for gaseous hydrogen unloading. The stanchion will consist of a flexible pigtail, shut-off valve, check valve, bleed valve, and necessary piping. Filling apparatus will be separated from other equipment for safety and convenience, and protected with walls or barriers to prevent vehicular collision.

II. DESIGN DESCRIPTION (Continued)

A. Design Criteria (Continued)

4. Hydrogen Supply (Continued)

A tube trailer grounding assembly will be provided for each discharge stanchion to ground the tube trailer before the discharge of hydrogen begins.

b. Cryogenic Tank

The tank will be constructed with an "inner vessel" or "liquid container" supported within an "outer vessel" or "vacuum jacket," with the space between filled with insulation and evacuated. Necessary piping will connect from inside of the inner vessel to outside of the vacuum jacket. Gages and valves to indicate the control of hydrogen in the vessel will be mounted outside of the vacuum jacket. Legs or saddles to support the whole assembly will be welded to the outside of the vacuum jacket.

The inner vessel will be designed, fabricated, tested, and stamped in accordance with Section VIII, Division 1 of the ASME Code for Unfired Pressure Vessels. Materials suitable for liquid hydrogen service must have good ductility properties at temperatures of -422°F per CGA G-5. In addition to ASME Code inspection requirements, 100% radiography of the inner vessel longitudinal welds will be completed. The tank outer vessel will be constructed of carbon steel and does not require ASME certification.

Insulation between inner and outer vessels will be either perlite, aluminized mylar, or a suitable equivalent. The annular space will be evacuated to a high vacuum of 50 microns or less.

Tank control piping and valving will be installed in accordance with B31.3. All piping will be either wrought copper or stainless steel. The following tank piping subsystems will be provided:

- Fill circuit, constructed with top and bottom lines so that the vessel can be filled without affecting continuous hydrogen supply.

- Pressure-built circuit, to keep tank pressures at operational levels.

- Vacuum-jacketed liquid fill and pump circuits, where applicable.

II. DESIGN DESCRIPTION (Continued)

A. Design Criteria (Continued)

4. Hydrogen Supply (Continued)

c. Overpressure Protection System

Safety considerations for the tank will be satisfied by dual full flow safety valves and emergency backup rupture discs. The primary relief system will consist of two sets of a minimum of one rupture disk and safety valve piped into separate "legs". Relief devices will be connected in parallel with other relief devices. The system will be coupled by a 3-way diverter valve or tie bar interlock so that one leg is opened when the other is closed. With this arrangement, a minimum of one safety valve and one rupture disk will be available at all times. The dual primary relief systems with 100% standby redundancy allows maintenance and testing to be performed without sacrificing the level of overpressure protection.

The primary relief system will comply with the provisions of the ASME Pressure Vessel Codes and the Compressed Gas Association (CGA) Standards.

The tank will also be supplied with a secondary relief system not required by the ASME Codes. This system will be totally separate from the primary relief system. It will consist of a locked open valve, a rupture disk, and a secondary vent stack. This rupture disk will be designed to burst at 1.33 MAWP.

Supply system piping that may contain liquid and can be isolatable from the tank relief valves will be protected with thermal relief valves. All outlet connections from the safety relief valves, rupture devices, bleed valves, and the fill line purge connections will be piped to an overhead vent stack, per CGA C-5, Section 7.3.7.

Two relief devices will be installed in the tank's outer vessel to relieve any excessive pressure buildup in the annular space.

Hydrogen tanks and delivery vehicles will be grounded per CGA P-12, Sections 5.4.5 and 5.7.1.2.

d. Seismic and Tornado Design

Design requirement for seismic and tornado loading will ensure that the oxygen and hydrogen storage tanks and gaseous hydrogen tube bank remain at their original location during a design basis tornado or earthquake so that any liquid spillage will originate from that location. The liquid piping will be seismically designed and supported as dictated by the Monticello response spectrum.

II. DESIGN DESCRIPTION (Continued)

A. Design Criteria (Continued)

4. Hydrogen Supply (Continued)

e. Siting Criteria

The site selected for the liquid hydrogen storage tank is east of the east cooling tower 1100 feet from the nearest safety related building (Figure 4). Appendix B to Reference (1) allows a 9000 gallon liquid hydrogen tank to be approximately 600 feet from a structure with 18 inch reinforced concrete walls (the safety related walls at Monticello are 18 inch thick reinforced concrete walls). A separation of 1100 feet is conservative. The sheet metal walls at the top of the Reactor Building may be damaged, however. Bechtel Power Corporation is currently performing analyses to confirm that the structural steel will remain intact and that there will be no large missiles to cause damage to fuel stored in the spent fuel pool. This is protection equivalent to that now provided to the top floor of the Reactor Building for tornado and severe weather conditions.

Hydrogen delivery trucks will momentarily pass at shorter distances from the reactor building using the site access road to the storage facility (Figure 4). The closest approach to the Reactor Building is approximately 450 feet. It is estimated that hydrogen delivery trucks will spend less than two hours per year on the plant access road. Therefore, this is not a significant risk.

The hydrogen tank will be at an elevation higher than the 100 year flood, therefore, no further consideration of flood induced loads is needed.

Transportable gaseous tube trailers, which would be used during plant testing, would be sited at the same location.

5. Oxygen Supply

a. Equipment Description

Liquid oxygen will be stored in a vacuum-jacketed vessel at pressures up to 250 psig and temperatures up to -250°F (saturated). Oxygen taken from the vessel will be vaporized through ambient air vaporizers and routed through a pressure control station which will maintain gas pressures within the desired range. The liquid oxygen system shall be provided by a supplier who has extensive experience in the design, operation, and maintenance of gas storage and supply systems. Liquid oxygen will be provided per CGA G-4 and G-4.3.

II. DESIGN DESCRIPTION (Continued)

A. Design Criteria (Continued)

5. Oxygen Supply (Continued)

a. Equipment Description (Continued)

The tank for oxygen service will be constructed with an "inner vessel" or "liquid container" supported within an "outer vessel" or "vacuum jacket", with insulation provided in the space between the tanks. Necessary piping connects from inside of the inner vessel to outside of the vacuum jacket. Gages and valves will be mounted outside of the vacuum jacket. Legs or saddles to support the whole assembly will be welded to the outside of the vacuum jacket.

The inner vessel will be designed, fabricated, tested and stamped in accordance with Section VIII, Division 1, of the ASME Code for Unfired Pressure Vessels. Materials will have good ductility properties at cryogenic temperatures of -300°F per CGA G-4. The outer vessel will be constructed of carbon steel and does not require ASME certification.

The vaporization of the liquid oxygen will be achieved by ambient air vaporizers. They will be sized to meet full flow requirements. The pressure control station will be of a manifold design. The manifold will have two full-flow parallel pressure reducing regulators. The discharge pressure range of these regulators will be adjustable to satisfy plant oxygen injection requirements. Pressure gauges will be provided upstream and downstream of the regulators and sufficient valves will be provided to ensure operational flexibility.

Protection of downstream equipment from low oxygen temperatures will be included in the system design.

All piping, fittings, valves and other material which may contact oxygen will be cleaned to remove internal organic, inorganic, and particulate matter in accordance with CGA-4.1. Observation has shown that ignition can occur in properly designed piping systems when foreign matter is introduced. Cleaning will be accomplished by precleaning all parts of the system, maintaining cleanliness during construction, and by completely cleaning the system after construction if needed.

II. DESIGN DESCRIPTION (Continued)

A. Design Criteria (Continued)

5. Oxygen Supply (Continued)

b. Siting Criteria

The site selected for the liquid oxygen storage tank is consistent with criteria presented in Section 4.4 of Reference (1). The tank will be in the same general area as the hydrogen tank, approximately 1100 feet from the nearest air intake to a safety related building (Figure 4). Since Figure 4-9 of the EPRI report allows a 9000 gallon liquid tank to be approximately 1060 feet from an air intake, it is concluded that the selected location is conservative and appropriate for a tank with a capacity of 9000 gallons or smaller (the largest size that will be used).

The separation distances between bulk hydrogen and oxygen as described in NFPA 50 and NFPA 50B will be maintained.

A transportable gaseous tube trailer is the probable choice for gas supply during system testing since the liquid system is not expected to be installed in time for the test. The oxygen tube trailer will meet the same standards as the hydrogen tube trailer. (See Section II.A.4.a). The tube trailer will be located in the same area as the permanent supply, thus meeting the NFPA separation requirements, and providing a conservative separation distance from the plant.

II. DESIGN DESCRIPTION (Continued)

B. Materials, Codes and Standards

Piping connected to existing plant systems will meet the requirements of the ASME Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Plant Components", Division I, 1977 Edition with all addenda up to and including Summer of 1978 Addendum. The piping will be installed in accordance with ANSI B31.1, 1977 Edition with all addenda through Winter 1978 Addendum. Use of ANSI B31.1 with material and weld properties qualified for use of $-50^{o}F$ is more conservative then the use of ANSI B31.3

The oxygen piping will meet the requirements of 29CFR1910.104 and NFPA50. The hydrogen piping will meet 29CFR1910.103, NFPA50, and 50.B except that the pipe will conform to ANSI B31.1, 1977 Edition with addenda through Winter 1978 with impact testing to -50°F.

Weld procedures will be qualified to additional toughness testing requirements consistent with ANSI B31.3.

All welding and brazing will be performed by welders who are qualified and with procedures that are written and qualified in accordance with ASME Code, Section IX.

Non-destructive examination requirements and acceptance criteria for piping will be in accordance with ANSI B31.1, 1977 Edition with addenda through Winter 1978 addenda.

Hydrogen and oxygen piping will be ASTM A333 Grade 6 except portions which are copper base. The oxygen piping will be cleaned to the requirements of Compressed Gas Association (CGA) Pamphlet G-4.1, "Equipment Cleaned for Oxygen Service".

Hydrogen valves will be packless to reduce the probability of leakage.

Oxygen injection control valves will be brass as recommended by Compressed Gas Association Pamphlet G-4.4. The piping attached to the valves will be copper base to preclude the dangers associated with reaching maximum velocities in carbon steel pipe. Carbon steel pipe has a lower ignition temperature than copper thus making copper a safer choice in high velocity areas such as downstream of modulating and on-off valves.

NFPA 70 will be adhered to for the electrical installation.

III. OPERATION

A. Start-Up

Before system start-up, the operator assures that all system valves are correctly positioned and that there are no abnormal alarms on the local annunciator.

When the plant power is above 30% load and hydrogen injection is to be initiated, the system control switch is placed in the "auto" position. This will sequentially place the hydrogen and oxygen injection systems in operation. In this mode of control, the oxygen flow system is in the "feedforward" mode, i.e., oxygen flow setpoint is a direct function of hydrogen flow.

B. Normal Operation & Shutdown

At operator discretion, the oxygen concentration controller can be placed in the "cascade" mode. Transfer of the control mode will be bumpless (i.e., there is no abrupt change in output). In this mode of control, the oxygen concentration at the recombiner outlet will throttle the oxygen flow control valve to achieve the desired oxygen concentration.

Hydrogen and oxygen can also be injected in the manual mode.

C. System Purging

If maintenance is required on in-line equipment after system shutdown, purging of the hydrogen or oxygen line by nitrogen may be required. Provision has been made to allow purging through the hydrogen or oxygen control valves.

D. Abnormal Operation & Shutdown

Hydrogen injection is terminated automatically and immediately (followed by automatic oxygen termination after a time delay) when one or more of the abnormal conditions occur. Manual reset of this automatic shutdown is required before the system can be restarted.

Upon detection of hydrogen gas in the process area or high hydrogen flow, in addition to the system shutdown mentioned above, the control valve at the hydrogen storage facility will also be closed to insure a complete shutoff of the gas supply.

IV. RADIOLOGICAL CONSIDERATIONS

Advanced Process Technology (APT) evaluated the radiological impact of increased Nitrogen-16 concentrations in the steam which will result following implementation of hydrogen water chemistry at Monticello. Dose rates in the turbine building, uncontrolled areas of the plant, and environs were measured in October, 1984 during plant shutdown and February, 1985 during plant full power operation. Operation with hydrogen water chemistry projected dose rates (measured dose rates increased by a factor of five) were used to evaluate the following:

1. dose to members of the public (40CFR190)
2. dose to personnel in uncontrolled areas of the plant (10CFR20)
3. operation of plant radiation monitoring equipment
4. maintenance of as low as reasonably achievable (ALARA) doses
5. routine surveillance and inspection of equipment in high radiation areas

The APT study assumed no mitigating action being taken for the increased dose rates from operation with HWC. The APT report concluded:

1. Monticello as currently shielded can operate with HWC at full power without exceeding the limits established by 40CFR190. Worst case offsite annual dose due to plant direct radiation will be less than 4 mRem/yr.

2. The expected dose rates in uncontrolled areas of the plant should not exceed 65% of the regulatory limit (10CFR20) assuming certain temporary trailers are relocated.

3. Implementation of HWC will have only a minor effect on plant radiation monitoring equipment.

4. Implementation of HWC without any mitigating actions will increase the total annual plant occupational dose by 14 man rem/yr. However, since future stress corrosion cracking damage will be virtually eliminated, several thousand man rem in maintenance exposure will be saved.

5. The current daily surveillance program in portions of the turbine building will have to be revised to keep doses ALARA.

Detailed radiological measurements will be taken during testing and operation of the hydrogen water chemistry system. Mitigating activities such as additional shielding and procedural changes will be evaluated and implemented in accordance with the Monticello ALARA Program using radiological measurements made during HWC testing and subsequent operation.

Increased doses due to HWC implementation may also affect the environmental qualification of electrical equipment. Environmental qualification data files will be reviewed by the Monticello technical staff and measures taken to ensure that compliance with 10CFR50.49 is maintained.

V. CRACK ARREST VERIFICATION

General Electric has developed a Crack Arrest Verification System (CAVS) which consists of reversing dc precision growth monitoring equipment for application with Hydrogen Water Chemistry (HWC). The CAVS provides continuous evidence that HWC application has stopped Intergranular Stress Corrosion Cracking (IGSCC).

The reversing dc system is a computer-controlled method of precision continuous crack growth monitoring. The system consists of test specimens designed so that the metallurgical condition and stress state are representative of key structural components such as pipes and safe ends. These specimens are contained in an autoclave that is connected to the recirculation system using a sample line. By continuously monitoring the performance of these specimens under Hydrogen Water Chemistry conditions, it will be possible to show that crack growth has been halted. It is also possible to monitor the effect of occasional conductivity transients in the coolant.

VI. SAFETY EVALUATION

The only expected changes to operating parameters as a result of the HWC system are an increase in the oxygen concentration in the off-gas effluent and an increase in steam line radiation due to increased Nitrogen-16. The off-gas system and components will be evaluated to assure there are no deleterious effects due to the increase in oxygen concentration. Data from radiation surveys will be utilized to assure continued compliance with 40CFR190, 10CFR20, and the Monticello "as low as reasonably achievable" (ALARA) Program.

The technical specification setpoint for the main steam line radiation monitor (MSLRM) is currently specified as less than or equal to 10 times normal full power background (i.e. normal steam line radiation levels without hydrogen addition). No technical specification change is required for the MSLRM setpoint since the expected increase in radiation levels will be well below a factor of ten.

Based on the intrinsic safety of the supply tanks and the conservative criteria used to select their locations as discussed in sections II.A.4 and II.A.5 of this report, the operation of plant safety systems is not affected by the worst consequences of hydrogen and/or oxygen vessel failure.

Provisions have been made for detection of hydrogen leakage and prompt isolation. Therefore no explosive mixtures will be created in the turbine building due to pipe rupture or failure of any component.

There will be no impact or any accident evaluation contained in Section 14 of the Updated Safety Analysis Report (USAR).

VI. SAFETY EVALUATION (Continued)

The Monticello USAR is updated on an annual basis. The appropriate sections of the USAR will be updated in the revision which follows by at least six months the return to full power operation following the modifications described in this report.

The plant can be operated in accordance with the current operating license with no modifications to the existing Technical Specifications.

VII. REFERENCES

1. Guidelines for Permanent BWR Hydrogen Water Chemistry Installation, 1987 Revision, Electric Power Research Institute Report NP-4500-SR-LD.

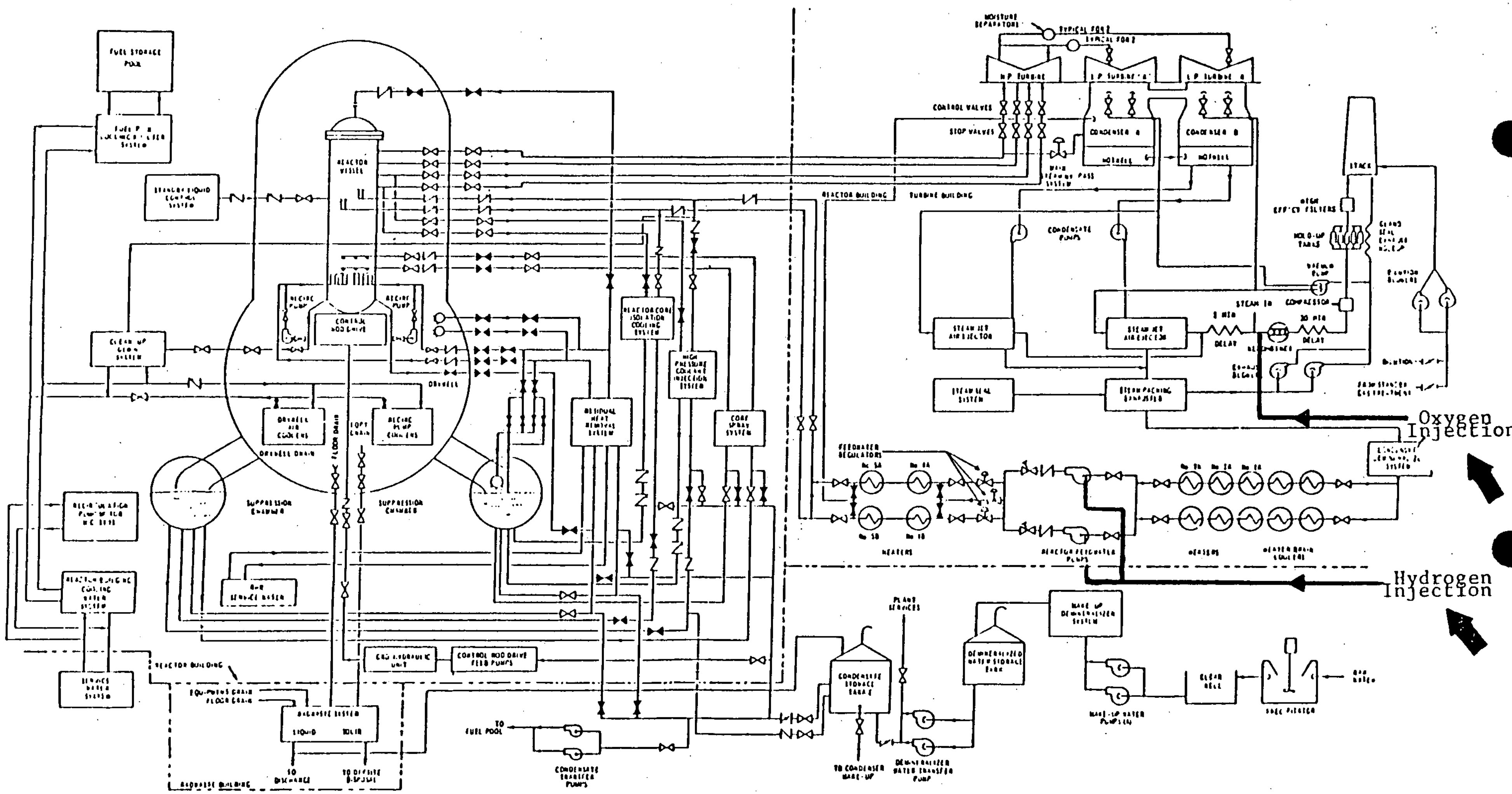


FIGURE 1

Hydrogen Water Chemistry Gaseous Addition Injection Points

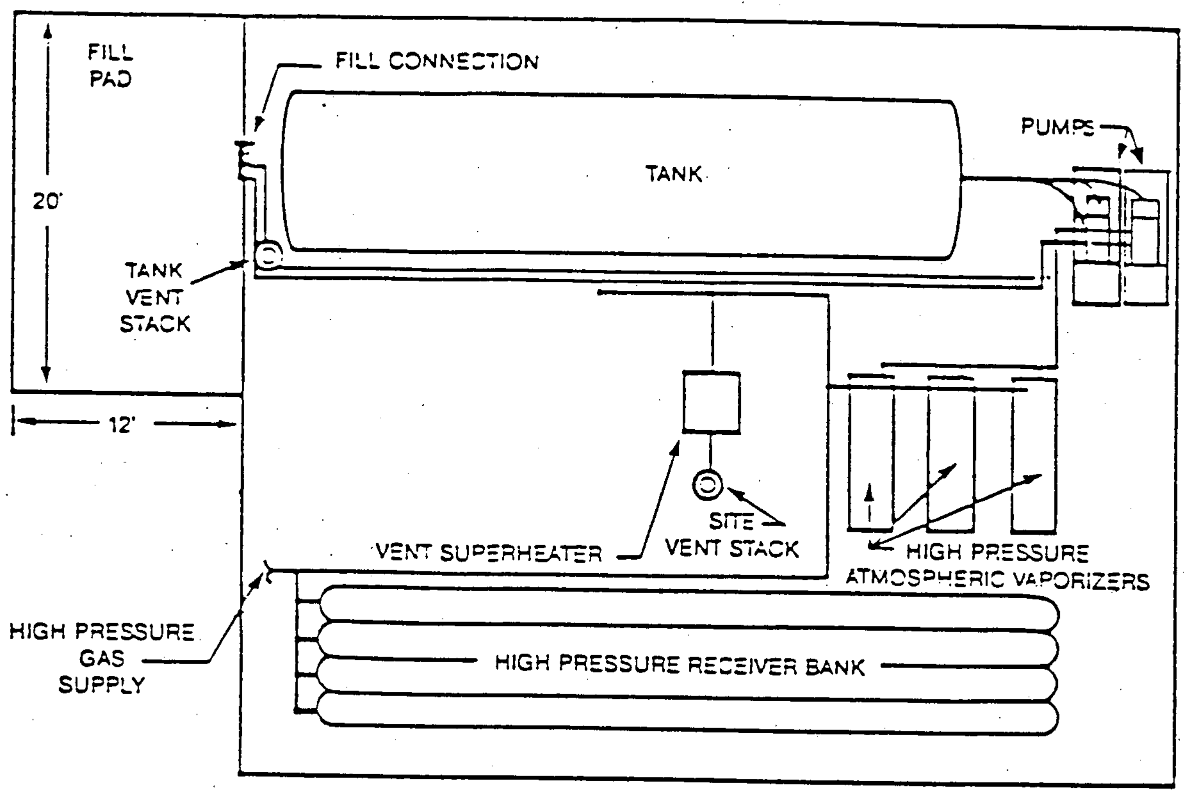


FIGURE 3

Typical Equipment Arrangement Hydrogen Pumping System

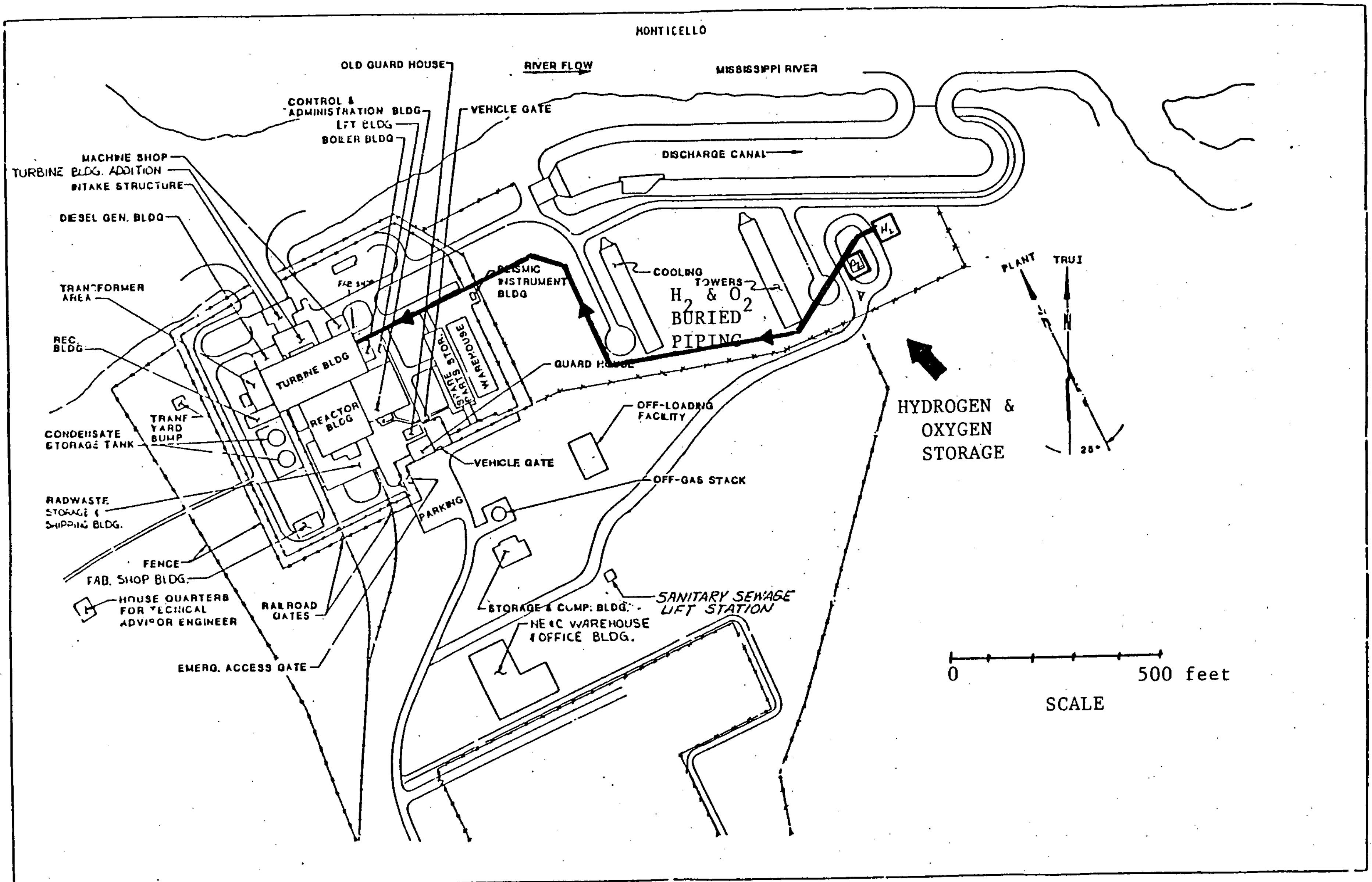
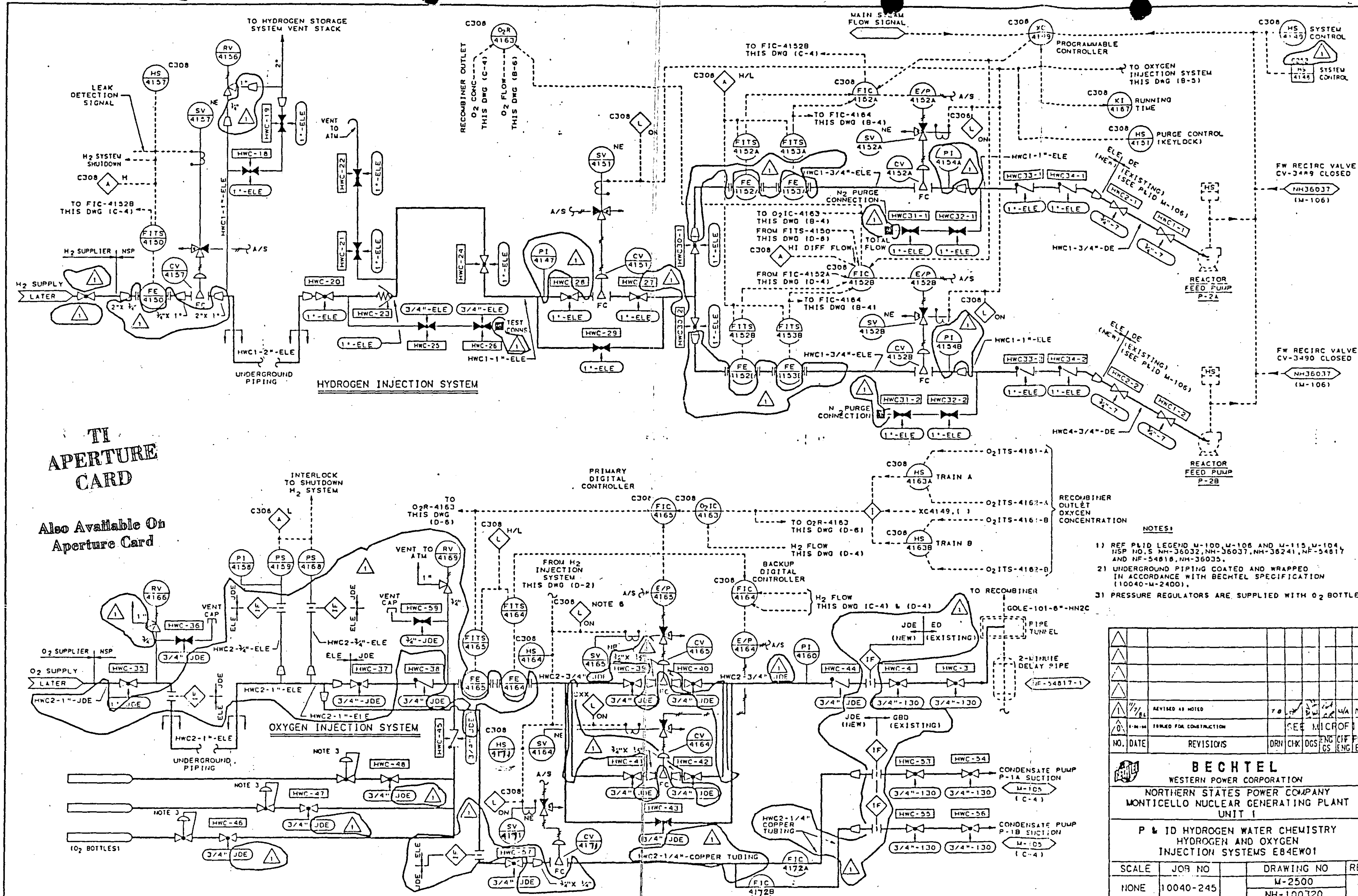


FIGURE 4

Hydrogen and Oxygen Storage Locations



NOTES:

1) REF P&ID LEGEND M-100, M-106 AND M-115, M-104, NSP NO.S NH-36032, NH-36037, NH-36241, NF-54817 AND NF-54818, NH-36035.
2) UNDERGROUND PIPING COATED AND WRAPPED IN ACCORDANCE WITH BECHTEL SPECIFICATION (10040-M-2400).
3) PRESSURE REGULATORS ARE SUPPLIED WITH O_2 BOTTLES.

NO.	DATE	REVISIONS	DRN	CHK	DGS	ENG GS	CHF ENG	PROJ ENG
1	11/7/86	REVISED AS NOTED						
0		ISSUED FOR CONSTRUCTION						

BECHTEL
WESTERN POWER CORPORATION

NORTHERN STATES POWER COMPANY
MONTICELLO NUCLEAR GENERATING PLANT
UNIT 1

P & ID HYDROGEN WATER CHEMISTRY
HYDROGEN AND OXYGEN
INJECTION SYSTEMS E84EW01

SCALE	JOB NO	DRAWING NO	REV
NONE	10040-245	M-2500 NH-100320	1

8704280434-01 FIGURE 2