PROPOSED TECHNICAL SPECIFICATION REVISION

A. RADIOACTIVE EFFLUENTS

EXPLOSIVE GAS MIXTURE

LIMITING CONDITION FOR OPERATION (McGuire Unit I)

Technical Specification 3.11.2.6 now reads as follows:

3.11.2.6 "The concentration of hydrogen and/or oxygen in the waste gas holdup system shall be limited to ≤ 2% by volume."

Technical Specification 3.11.26 should be changed to read as follows:

3.11.2.6 The concentration of oxygen in the waste gas holdup system shall be limited to ≤ 3% by volume.

APPLICABILITY: At all times.

ACTION:

a. With the concentration of oxygen in the waste gas holdup system > 3% by volume but ≤ 4% by volume, restore the concentration of oxygen to within the limit in 48 hours.

b. With the concentration of oxygen in the waste gas holdup system > 4% by volume, immediately suspend all additions of waste gases to the system and reduce the concentration of oxygen to ≤ 3% within 48 hours.

SURVEILLANCE REQUIREMENTS

The Surveillance Requirements should be changed to read:

4.11.2.6 The concentration of oxygen in the waste gas holdup system shall be determined to be within the above limits by continuously monitoring the waste gases in the waste gas holdup system with the oxygen monitors required OPERABLE by Table 3.3-13 of Specification 3.3.3.10.

REASONS AND JUSTIFICATION FOR CHANGE

1) Below 5.0% Oxygen, no mixture of hydrogen and oxygen is flammable with nitrogen acting as the diluent in this mixture.[1] This is the case for the McGuire Waste Gas System.

2) "The fact that a combustible gas, vapor, or mist will not burn or explode when the oxygen content of the atmosphere is reduced below a certain definite value, varying with the combustible material under consideration, enables one to definitely control and in many cases actually eliminate explosion hazards."[2]

3) McGuire's Waste Gas System is designed to operate at low oxygen concentrations (below 15 ppm in the system, excluding portions of the recombiner skid) with a hydrogen recombiner in operation. The oxygen feed valve to the hydrogen recombiner can never pass more than 3.0% oxygen without causing an alarm which trips the oxygen feed valve closed. An inlet oxygen concentration to the hydrogen recombiner of $\geq$ 3.5% oxygen will cause both the oxygen feed valve and the Volume Control Tank hydrogen purge isolation valve (Unit I and II) to close.

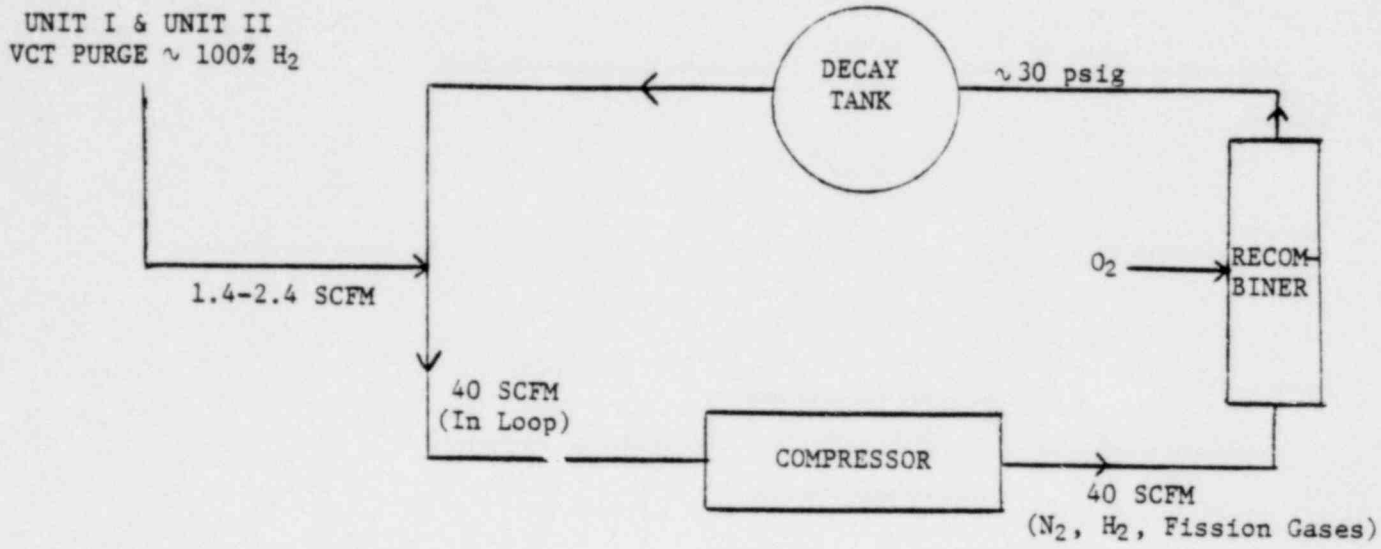
4) The Waste Gas System is designed for operation in one of the two following modes:

   (A) Compressor → Recombiner → Decay Tank
   (B) Compressor → Decay Tank → Recombiner

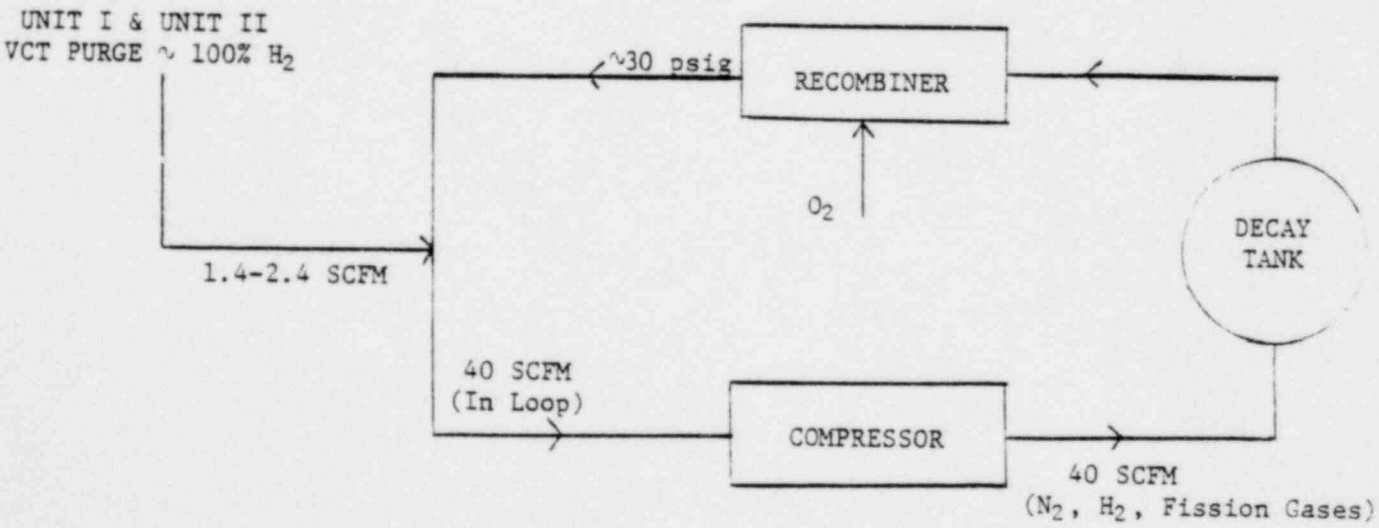
   Design of the system is such that operation begins in Mode (A) until approximately 25 psig is reached in the decay tank. At this point the valve alignment should be switched to Mode (B). The hydrogen purge from each VCT will normally be approximately 0.75 SCFM. With a combined VCT purge (both units) of 1.5 SCFM there is 3.75% hydrogen in the WG System at the point where this purge mixes with the WG loop flow (approximately 40 SCFM). The recombiner is designed to remove all but approximately 0.1% H_2 which will pass to the decay tank. When the decay tank reaches 20 - 25 psig, the valve alignment of Compressor → Decay Tank → Recombiner must be made due to the backpressure on the recombiner which exists with approximately 20 psig in the tank. (Maximum recombiner design pressure is 30 psig.)

   Mode B would normally be the means by which the tank in Mode A is used and filled to its allowable limit (approximately 100 psig -140 psig). However, as the Mode (B) diagram below shows, this would not be possible with the demands of the 3.11.2.6 Technical Specification.

MODE (A)


UNIT I & UNIT II
VCT PURGE ∿ 100% H_2
DECAY TANK
∿30 psig
O_2
RECOM-BINER
1.4-2.4 SCFM
40 SCFM
(In Loop)
COMPRESSOR
40 SCFM
(N_2, H_2, Fission Gases)

MODE (B)


UNIT I & UNIT II
VCT PURGE ∿ 100% H_2
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RECOMBINER
O_2
DECAY TANK
1.4-2.4 SCFM
40 SCFM
(In Loop)
COMPRESSOR
40 SCFM
(N_2, H_2, Fission Gases)

Example: Flow from Units I and II = 1.4 SCFM (100% H_2)

This would give a 3.5% H_2 concentration in the Waste Gas System loop, and eventually a 3.5% H_2 concentration in the WG Decay Tank in service. If the Decay Tank is at 25 psig (2.7 atmosphere), it would take approximately 40.5 minutes to reach this 3.5% H_2 concentration in the tank, based on the following estimate:

$$100\% \ (1.4 \ ft^3 \ H_2/min) = \frac{600 \ ft^3}{atm.} \ (x \ \%/min)(2.7 \ atm)$$

(tank volume)

$$= 100\% \ \left(\frac{1.4 \ ft^3 \ H_2}{min}\right) = 1620 \ ft^3 \ (x \ \%/min)$$

$$x = 0.0864 \ \%/min \text{ increase in tank } \therefore \quad \frac{3.5\%}{0.0864\%/min} = 40.5 \text{ min}$$

With 0 psig (1 atm) in decay tank it would take approximately 8.5 minutes to reach a 2% H_2 concentration which is the present Technical Specification limit. At 100 psig in the tank, within 60 minutes this 2% concentration would be reached.

This points to either a flaw in the normal modes of operation of the WG System or, more likely, a discrepancy between the Technical Specification and reasonable limits for operating the system in Mode (B).

5) Westinghouse Standard Technical Specifications (STS) word their specification for the explosive gas mixture in the Waste Gas holdup system similar to this:

> The concentration of oxygen in the waste gas holdup system shall be limited to $\leq$ 2% by volume.

Note that no mention of hydrogen concentrations exists in this statement.

6) "Before an explosive mixture can propagate flame a portion of the mixture must be heated to its ignition temperature."[3]

The minimum ignition temperature of hydrogen vapors in oxygen is 1067°F.[4]

The normal operating temperature of the hydrogen recombiners is approximately 850°F. An alarm and corresponding shutdown of the oxygen feed to the hydrogen recombiner occurs when the temperature in the recombiner catalyst bed reaches 1050°F. This high temperature can be detected by any one or more of the six thermocouples which are positioned at various levels throughout the recombiner catalyst bed. These thermocouples, along with five others located at specific point between the recombiner skid inlet and outlet valves, are wired to a chart recorder thereby providing the operator with continuous temperature monitoring capability. Additionally, there are six backup thermocouples already installed in the recombiner catalyst bed which can be used in the event that one of the normally used thermocouples fails.

7) "The usual problem in dealing with combustible mixtures is to control the atmosphere so that the composition at all times is outside the flammable range."[5]

Because the Waste Gas System is designed to operate within limits to prevent combustible mixtures, the above condition of operating outside of the flammable range is met. Only if there is a break in the Waste Gas piping could the potential for an explosive H_2 - O_2 mixture exist and even then the ignition temperature of 1050°F must be present.

In summary, a Technical Specification of $\leq$ 3% oxygen concentration in the Waste Gas holdup system is quite conservative, leaving a 40% margin of error between this limit and the limit of 5% oxygen for nonflammable oxygen-hydrogen mixtures.

Moreover, the Waste Gas System is designed with built-in safety shutdown features which prevent the oxygen-hydrogen concentrations from reaching flammable proportions. This is evidenced by the fact that the analyzers which measure oxygen inlet and outlet concentrations across the recombiner bed possess features which will shut off the oxygen supply to the system before flammable oxygen-hydrogen concentrations develop. If for some reason the inlet oxygen concentration to the recombiner reaches 3.5%, the inlet oxygen analyzer will not only close the oxygen supply valve but will close valve 1WG3 and 1WG14 which are the hydrogen purge isolation valves from Unit I and Unit II Volume Control Tanks respectively.

The hydrogen analyzers in the Waste Gas System are also designed with alarm and/or shutdown features. The hydrogen analyzer which monitors the inlet hydrogen concentration to the recombiner will trigger an alarm at 6.0% hydrogen and shut off the oxygen supply to the recombiner at concentrations of $\geq$ 9.0% hydrogen. The other hydrogen analyzer monitors the concentration of hydrogen as it leaves the recombiner and modulates the oxygen addition valve to maintain proper oxygen-hydrogen mixtures for safe, automatic operation.

Inputs to the Waste Gas System from sources other than the VCT Purge header have been determined to be of low enough oxygen or hydrogen concentration as to minimize interference with the normal operation of the Waste Gas System. The Pressurizer Relief Tank appears to be the source which could contribute the largest volume of gas at one time to the Waste Gas System; however, this is mostly nitrogen and should only impact the system gas composition for short periods of time, such as during plant startup.

References

[1] Patty, Frank A. Industrial Hygiene and Toxicology. Volume I. General Principles. Interscience Publishers, Inc. New York. Pgs. 539-540.
[2] ibid, P. 538.
[3] ibid, P. 524.
[4] ibid, P. 534.
[5] ibid, P. 541.