An Analysis of Hydrogen Control Measures
at McGuire Nuclear Station
Revision 8

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Volume 3

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3.4 SYSTEM DESCRIPTION AND FUNCTION

The Hydrogen Mitigation System consists of 72 glow plug ignition devices (igniters), as shown in Figure 3.4-1, located in 36 areas of the containment. 8
Each location has an igniter assembly powered from an A circuit and an igniter assembly powered from a B circuit and connected to one or more auxiliary ac circuits powered from Emergency Lighting Panelboards in the Auxiliary Buildings. These Emergency Lighting Panelboards can be manually loaded onto the diesel generators. A and B train redundancy is retained back to the diesel generators. Igniter circuit descriptions are shown in Table 3.4-1 and Figure 3.4-2.

Each igniter assembly terminal box contains a transformer to convert the 120 volt lighting circuit supply to the 14 ± 1 volt required by the glow plug igniter to attain a temperature of 1600°F. The transformer is enclosed in a watertight metal case; the igniter is mounted through one of the sides of the case with the hot end protruding beyond the box profile. The box also features a removable front cover, a copper heat shield on the igniter side, and a drip shield above the hot end of the igniter. Igniter boxes are mounted on cable tray or other seismically mounted structures.

The locations of the igniters in the containment are shown in Figures 3.4-3 through 3.4-6. There are no compartments in the Reactor Building without direct coverage by igniters. Because of the importance of the igniters in the ice condenser upper plenum to the control of hydrogen burning, an analysis was performed to ensure that an adequate number of igniters was mounted in

the ice condenser upper plenum. The analysis showed that six igniters spaced approximately equally will prevent hydrogen concentrations greater than 10% by volume in the ice condenser at any location if ignition takes place at 8.5% hydrogen by volume and propagation is at one foot/second, for the maximum hydrogen release rate predicted for the McGuire small break LOCA. Because 10% is considerably below any plausible detonation limit, this design criterion is conservative.

Power to the igniter system is supplied by 12 circuit breakers, six each on 8
Emergency Lighting Panelboards ELA1 and ELB1. These circuit breakers, panelboards, and associated connections to Class 1E power sources are shown on Figures 3.4-7 and 3.4-8 for ELA1 and ELB1 respectively. The connection diagram for the igniters themselves, which indicates the number and location of igniters connected to each circuit, is shown in Figure 3.4-9. Periodic measurements to establish the operability of the igniters are made at Emergency 6
Lighting Panelboards ELA1 and ELB1.

Because each region of containment is supplied by at least one redundant pair of igniters, a failure which renders a single igniter inoperable, or which causes the failure of all igniters associated with a single circuit or panelboard, will not affect the ability of the hydrogen ignition system to perform its intended function.

The function of the Hydrogen Mitigation System is to ignite mixtures of hydrogen and oxygen in the various areas of the containment when the local concentration of hydrogen has reached 8.5%. The early ignition of hydrogen in the containment has several benefits.

Table 3.4-1

GLOW PLUG LOCATIONS

TERM. BOX NO.	ROOM; AREA	ELEVATION
1EHMTB-1	Incore Tunnel	720' + 0"
1EHMTB-2	Incore Tunnel	720' + 0"
1EHMTB-3	Pipe Chase @ 5°	735' + 0"
1EHMTB-4	Pipe Chase @ 9°	735' + 0"
1EHMTB-5	Pipe Chase @ 88°	735' + 0"
1EHMTB-6	Pipe Chase @92°	735' + 0"
1EHMTB-7	Pipe Chase @ 178°	735' + 0"
1EHMTB-8	Pipe Chase @ 182°	735' + 0"
1EHMTB-9	Pipe Chase @ 273°	735' + 0"
1EHMTB-10	Pipe Chase @ 277°	735' + 0"
1EHMTB-11	L.C. Vent.Rm.@ 2°	763' + 0"
1EHMTB-12	L.C. Vent.Rm.@ 6°	763' + 0"
1EHMTB-13	Acc. Rm. 1A @53°	763' + 0"
1EHMTB-14	Acc. Rm. 1A @53°	763' + 0"
1EHMTB-15	Incore Rm. @ 91°	763' + 0"
1EHMTB-16	Incore Rm. @ 96°	763' + 0"
1EHMTB-17	Acc. Rm. 1B @145°	763' + 0"
1EHMTB-18	Acc. Rm. 1B @145°	763' + 0"
1EHMTB-19	L.C. Vent.Rm@172°	763' + 0"
1EHMTB-20	L.C. Vent Rm @176°	763' + 0"
1EHMTB-21	Acc. Rm. 1C @214°	763' + 0"
1EHMTB-22	Acc. Rm. 1C @214	763' + 0"
1EHMTB-23	Refuel Access@245°	763' + 0"
1EHMTB-24	Refuel Access@249°	763' + 0"
1EHMTB-25	Acc.Rm. 1-D @325°	763' + 0"
1EHMTB-26	Acc.Rm. 1-D @325°	763' + 0"
1EHMTB-27	Below Oper. Fl. @ 55°	774' + 0"
1EHMTB-28	Below Oper. Fl. @ 55°	774' + 0"
1EHMTB-29	Primary Shield Wall	775' + 0"
1EHMTB-30	Primary Shield Wall	775' + 0"
1EHMTB-31	Below Oper. Fl. @ 121°	774' + 0"
1EHMTB-32	Below Oper. Fl. @ 121°	774' + 0"
1EHMTB-67	inside crane wall at 85°	730' + 0"
1EHMTB-68	inside crane wall at 85°	730' + 0"
1EHMTB-69	on steam generator enclosure at 140°	822' + 0"
1EHMTB-70	on steam generator enclosure at 220°	822' + 0"
1EHMTB-71	on steam generator enclosure at 320°	822' + 0"
1EHMTB-72	on steam generator enclosure at 40°	822' + 0"

TERM BOX NO.	ROOM; AREA	ELEVATION
1EHMTB-33	Below Oper. Fl. @ 216°	774' + 0"
1EHMTB-34	Below Oper. Fl. @ 216°	774' + 0"
1EHMTB-35	Below Oper. Fl. @ 326°	774' + 0"
1EHMTB-36	Below Oper. Fl. @ 326°	774' + 0"
1EHMTB-37	Steam Gen. 1-A @18°	816' + 0"
1EHMTB-38	Steam Gen. 1-A @22°	816' + 0"
1EHMTB-39	Pressurizer @ 114°	814' + 0
1EHMTB-40	Pressurizer @ 114°	814' + 0"
1EHMTB-41	Stm. Gen. 1-B @161°	816' + 0"
1EHMTB-42	Stm. Gen. 1-B @165°	816' + 0"
1EHMTB-43	Stm. Gen.1-C @206°	816' + 0"
1EHMTB-44	Stm. Gen.1-C @210°	816' + 0"
1EHMTB-45	Stm. Gen.1-D @335°	816' + 0"
1EHMTB-46	Stm. Gen.1-D @339°	816' + 0"
1EHMTB-47	Ice Condenser @42°	839' + 0"
1EHMTB-48	Ice Condenser @46°	839' + 0"
1EHMTB-49	Ice Condenser @129°	839' + 0"
1EHMTB-50	Ice Condenser @133°	839' + 0"
1EHMTB-51	Ice Condenser @221°	839' + 0"
1EHMTB-52	Ice Condenser @225°	839' + 0"
1EHMTB-53	Ice Condenser @321°	839' + 0"
1EHMTB-54	Ice Condenser @325°	839' + 0"
1EHMTB-55	Dome @ 49°	887' + 0"
1EHMTB-56	Dome @ 57°	887' + 0"
1EHMTB-57	Dome @ 132°	887' + 0"
1EHMTB-58	Dome @ 140°	887' + 0"
1EHMTB-59	Dome @ 218°	887' + 0"
1EHMTB-60	Dome @ 226°	887' + 0"
1EHMTB-61	Dome @ 310°	887' + 0"
1EHMTB-62	Dome @ 318°	887' + 0"
1EHMTB-63	Ice Condenser @108°	840' + 0"
1EHMTB-64	Ice Condenser @184°	840' + 0"
1EHMTB-65	Ice Condenser @ 12°	840' + 0"
1EHMTB-66	Ice Condenser @ 85°	840' + 0"

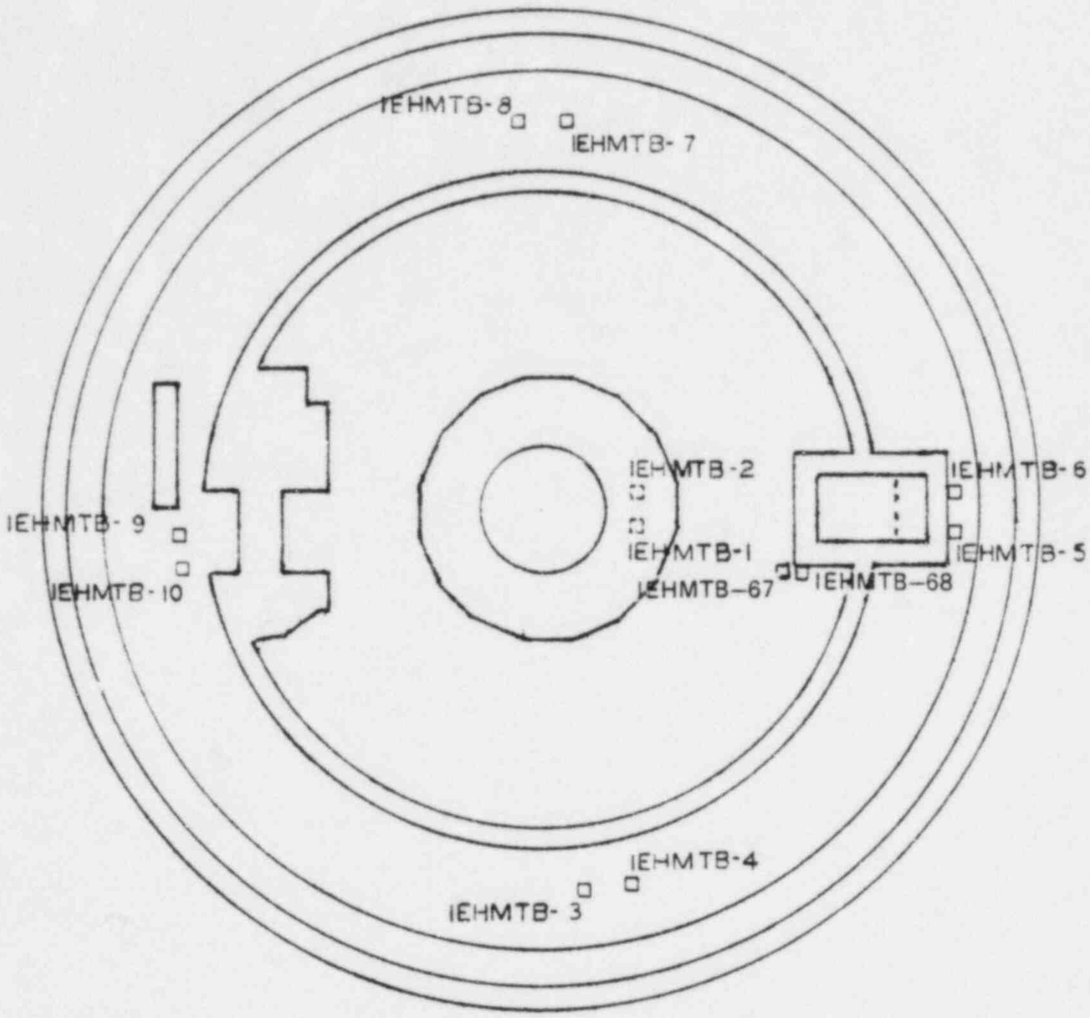
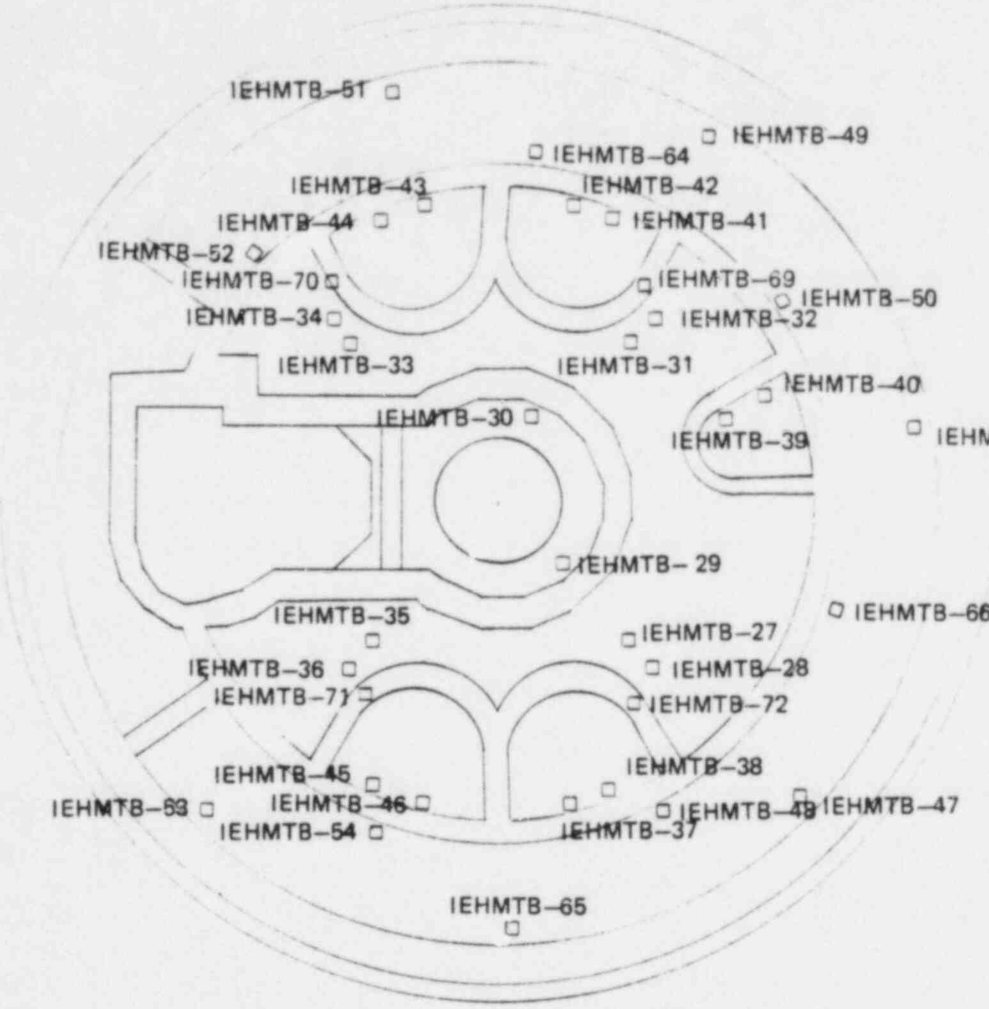


Figure 3.4-3

McGuire Containment - Section at EL 738



Note: Igniters in upper plenum or ice condenser are at elevation 840'.

FIGURE 3.4-5

M^cGUIRE CONTAINMENT-PLAN @ ELEV. 820+0

5.4.3 Instrumentation Transmitters

On the list of essential equipment in containment are the narrow range steam generator level transmitters. These devices are Barton model 764 (lot 2), with the qualification results described in Westinghouse document WCAP-9885. These transmitters are located in dead ended compartments (accumulator rooms) where CLASIX predicts no burning. However, a forcing function for burning including one flame and the associated temperature rise was imposed on the transmitter simply to assess whether the transmitter was likely to undergo substantial temperature rise during hydrogen burning. Assumptions used were similar to those for the analysis of small diameter cable, with flame speed of two feet/second, burning occurring at 8.5% hydrogen by volume, and all three modes of heat transfer considered simultaneously, including radiation from a moving flame front.

Analysis showed that the single burn produced a temperature rise of less than 10°F on the interior of the transmitter, thus temperatures will remain within the capability of the transmitter based on its previous qualification, even when subjected to multiple burns.

Similar analysis and conclusions apply to the pressurizer level transmitter, which is of the same model and located in the same area as the narrow range steam generator level transmitter.

5.4.4 Additional Equipment

This section discusses the survivability of additional essential equipment during hydrogen burning. Survivability is based on comparison with FSAR 8

accident analysis containment conditions for a main steamline break (MSLB) in the lower compartment and dead-ended compartments (McGuire FSAR, Figure 7, page Q042-54) and on large break loss of coolant accident (LOCA) response for the upper compartment (McGuire FSAR, Figure 6.2.1-24). Reference conditions for hydrogen burning in containment are given in Figures 4.6-1 through 4.6-5, the reference case CLASIX analysis. Each essential component is discussed in terms of its expected environment during FSAR accident conditions compared with the environment during hydrogen burning. All essential equipment in containment has been qualified for conditions equal to or worse than the containment conditions shown in the referenced FSAR figures.

1. <u>Pressurizer Power Operated Relief Valves and Block Valves</u> - The equipment qualificatin for these components is based on the lower compartment MSLB conditions referenced previously. A comparison between these conditions and the reference containment conditions during hydrogen burning shows that the conditions during hydrogen burning are not as severe as those for the MSLB conditions. Whereas, the individual hydrogen burns cause compartment temperatures to rise temporarily above the MSLB temperature, these excursions are of very short duration (typically 30 seconds), and the temperature of containment during the period between individual hydrogen burn events falls well below the MSLB temperature for much longer periods of time (typically 200 seconds). The result is that total energy transfer from the containment environment to the equipment will be lower for the hydrogen-burning events than it is for the MSLB case. It is therefore concluded that the pressurizer power operated relief valves and associated block valves will survive the hydrogen-burning environment.

2. Core Exit Thermocouples - These components are located within the reactor core and are, therefore, not exposed to the hydrogen-burning environment. The cables associated with the core exit thermocouples have been shown to survive hydrogen burning in accordance with the discussion in Section 5.4.

3. Reactor Coolant Loop Wide-Range RTD - These components are installed in thermal wells within the reactor coolant piping and are, threfore, not exposed to the hydrogen-burning environment. The survivability of the cabling associated with the RTD's was addressed in Section 5.4. It is, therefore, concluded that the normal operating temperature and MSLB temperatures cause much greater temperatures for the RTD's than would be created by hydrogen burning and, therefore, the RTD's will survive hydrogen burning.

4. Hydrogen Recombiner and Containment Air Return Fan - These components are located in the upper containment where the CLASIX analysis has shown that no hydrogen burning occurs. The response of the upper containment to FSAR LOCA conditions is more severe than the response to hydrogen burning and, therefore, envelopes the hydrogen burning environment. Accordingly, it is concluded that equipment in the upper compartment, such as the hydrogen recombiners and air return fans, will survive hydrogen burning based on their qualification for upper containment LOCA conditions.

5. Electrical Penetrations - These components are located in the dead-ended compartment areas of containment. These are the rooms which contain the cold leg accumulators and lower containment cooling units. No hydrogen burning occurs in these compartments, therefore, the MSLB containment

conditions, to which the electrical penetrations are qualified, envelope the containment conditions during hydrogen burning with considerable margin. Accordingly, it is concluded that electrical penetrations will survive hydrogen burning.

An evaluation was performed to determine whether increases in flame speed or the presence of hydrogen burning in the dead-ended compartments or upper containment would affect these conclusions. Changes in flame speed from the reference case do not change the temperature response of containment compartments in a significant way; increases in average containment temperature by 10-20°F are offset by shorter duration of hydrogen burns and, therefore, shorter duration of temperature excursions above MSLB conditions. This is explained by the integrating effect of the large number of massive structural heat sinks which tend to cause containment response to be a function of the total energy release from hydrogen burning rather than the rate of energy release from hydrogen burning. The question of effects of hydrogen burning in the dead-ended compartments was addressed specifically in Section 5.4.3 for Barton instrumentation transmitters. The electrical penetrations are more massive and much more favorably located with respect to heat sinking than these transmitters. It is, therefore, concluded that hydrogen burning, even if postulated to occur in the dead-ended compartment, would have no significant effect on the penetrations or the Barton transmitters. Because of the large amount of hydrogen consumed in the upper compartment during a burn, one can reasonably postulate only a single upper compartment burn and then only if other unrealistic assumptions concerning failure of the hydrogen mitigation system are made. This single burn produces a temperature excursion above LOCA conditions for approximately 40 seconds.

It is concluded that this short duration temperature rise will have no significant effect on the operability of either the hydrogen recombiner or the air return fans due to the margins available for these components when the background ambient for hydrogen burning (125°F) is compared with the FSAR LOCA temperature (greater than 150°F for approximately two hours).

It is concluded that all essential equipment will survive hydrogen burning. This has been shown by analysis and comparison to qualification temperature for small components with rapid temperature responses and by quantitative comparison between the predicted containment response during a LOCA with hydrogen burning as presented in Section 4.0 and the appropriate FSAR containment response curves for which the equipment was originally qualified.

Duke Power Company Response to Proposed

Enhancements to the McGuire Hydrogen Mitigation System

Transmitted by Letter from Ms. E. G. Adensam, Dated March 16, 1983

General Discussion

Two of the three enhancements proposed by the staff are based on the perception that hydrogen igniters located close to the top of containment compartments are less effective than those located at lower elevations or on the floor of compartments. Prior to discussing these specific cases, a general discussion of the rationale for hydrogen igniter location will be presented.

There are several reasons why Duke chose to locate all hydrogen igniters close to the top of containment compartments. For equipment protection, it was desirable to locate the relatively vulnerable igniter assemblies in areas where personnel were unlikely to contact them. This also constitutes increased personnel safety during testing. Locations at or near the top of compartments also are the least likely to be areas of concern from pipe whip or jet impingement. There is also some validity to the argument that locations close to the top of compartments cause igniters to be located in areas of highest hydrogen concentration if concentration gradients exist in compartments, though this is no longer a major consideration because our research has shown that turbulence levels are sufficient to overcome buoyancy-induced concentration gradients.

For McGuire, an analysis was performed on the basis of a global burning, with ignition projected to occur at the laminar downward propagation concentration of 8.5% H_2 by volume, and flame speeds based on downward laminar burning velocities. However, it should be noted that such assumptions made for calculational purposes are not based on actual containment behavior. Experimental evidence from several sources shows that hydrogen igniters reliably ignite hydrogen at concentrations as low as 5% if turbulent mixing is available [1, 2]. In addition, turbulent mixing has been shown to cause downward propagation in mixtures of 5% and 7% hydrogen, and to cause burn completions of 70-100% in the same concentration when the igniter is located at the top of the vessel [2]. This evidence does not support a conclusion that hydrogen burning at McGuire occurs only at concentrations of 8.5% or that all hydrogen burns at McGuire will be global burns, though the response of the containment to a burn sequence based on this conclusion will most likely represent a conservative assessment of containment response.

Accepting the conclusion that some hydrogen burning will occur at concentrations of 5-6%, we are faced with the problem of assessing how much hydrogen will be consumed in this manner. The amount of hydrogen burned will be dependent on the amount consumed per ignition, and the number of ignitions per unit time. The effects of turbulence again become of great importance, because turbulence is known to cause global propagation of hydrogen flames at hydrogen concentrations well below the downward propagation limit [3]. Assessing the performance of the hydrogen mitigation system in the presence of turbulence therefore becomes a tough call. However, it may not be concluded that ignition sources located at lower elevations necessarily always lead to milder responses. As illustrated in another recent test [4], the total pressure rise during a hydrogen burn may be higher for an ignition source

located at lower elevations in a vessel than for top ignition under nearly identical conditions. If an ignition source at a lower elevation in a vessel fails to ignite hydrogen at low concentrations, perhaps because the flammable mixture bypasses the ignition source and accumulates in the parts of the vessel away from the ignition source, then the pressure response upon initiation of a global burn at a lower elevation will be worse due to the faster upward propagation and shorter vessel burnout time.

In summary, the following conclusions may be drawn concerning a system of igniters located predominantly at higher elevations in containment compartments:

1. Ignition sources at or near the top will reliably ignite global burns if the hydrogen concentration rises to the downward propagation limit (8.5%) in quiescent conditions.

2. Under turbulent conditions, any ignition source can be expected to initiate hydrogen burning at hydrogen concentrations below 8.5%, and, with sufficient turbulence, promote global or near global burning by propagation of flames in all directions.

3. Ignition sources at lower elevations do not always create the most benign response. Indeed, for ignition occurring at a given hydrogen concentration, igniters at high elevations will always create lower responses than igniters at lower elevations due to the lower velocity of downward propagation and the greater distance of the hydrogen igniters from the opposite end of the compartment. One must therefore be absolutely sure that igniters at lower elevations are going to ignite

hydrogen at lower concentrations than those at higher elevations if a positive benefit is to be gained from igniters at lower elevations.

Additional Upper Compartment Igniters

In assessing the need for additional igniters in the upper compartment, the following questions need to be addressed:

1. What is the probability that an ignitable concentration leading to a global burn will accumulate in the upper compartment?

2. Given such an ignitable concentration in the upper compartment, what are the consequences of burning hydrogen there, considering the present arrangement of ignition sources?

3. If the consequences of burning with the present arrangement of ignition sources is unacceptable, what action, such as the use of additional igniters, should be taken?

If we define an ignitable concentration for global burning as 8.5% hydrogen or above, and use the CLASIX code for analysis of hydrogen concentration in the upper compartment, we find that burning in the other containment compartments precludes the accumulation of enough hydrogen in the upper compartment to reach 8.5%. This is shown in our reference case analysis assuming no burning in any compartment until the H_2 concentration reaches 8.5%. If we preclude burning in the lower compartment, and require global burning at 8.5% in the upper plenum of the ice condenser, we again do not attain 8.5% in the upper compartment. It is only when we render the upper plenum completely ineffective

(do not permit even partial burning at 8.5%), and we take no credit for the existing igniters in the dome of the ice condenser until the global concentration in the upper compartment reaches 8.5%, that we are able to get a global upper compartment burn at 8.5% hydrogen. These assumptions are not considered realistic for the following reasons:

1. Concerning the upper plenum igniters, the only identified common mode failure of these devices is inerting of the upper plenum caused by a fog generated in the ice bed. The mechanisms by which such a fog could be generated, its characteristics, and its effect on hydrogen burning in the upper plenum were examined extensively in [5]. This analysis, which has been shown to have excellent agreement with experiments reported by [6], showed that the worst case outcome of fog generation in the ice bed was raising of the lower flammability limit in the upper plenum to 7.9% hydrogen on a dry basis. Examination of the CLASIX results in which the ignition of hydrogen in the upper plenum was completely inhibited for all hydrogen concentrations shows that the typical hydrogen concentration reached in the upper plenum, prior to attaining a concentration of 8.5% in the upper compartment, is 10.3% on a dry basis. It can be concluded that a fog produced in the ice bed cannot attain sufficient density to inhibit burning in the upper plenum, and that this upper plenum burning will preclude accumulation of 8-8.5% concentrations in the upper compartment.

2. The existing hydrogen igniters in the dome of the ice condenser will cause hydrogen burns with the least effect on containment integrity. The mixture of gases rising from the top deck of the ice condenser will be relatively free of water vapor due to the steam stripping action of the ice bed, and any fog will be substantially removed by the hotter walls

and lower velocity as the flow travels up the inside of the containment dome toward the igniters in the dome. Action of the containment sprays tends to create a low pressure area in the dome which will further enhance the flow toward the dome mounted igniters. Any hydrogen not burned at the dome igniters will be entrained in the spray and forced down the core of the containment and swept toward the air return fan suction. Thus location of hydrogen igniters in the dome of the containment represents the position most likely to burn hydrogen in a series of small burns rather than a global burn. Locations of the igniters at the midplane of the containment on the inside of the crane wall places them in a position of being bypassed by the hydrogen flow into containment and ensures that they will have no significant effect on the hydrogen in the upper compartment until a mixture susceptible to global burning is available. Any advantage to be gained by locating igniters below the dome must be evaluated considering the results of the previously cited experiment [4] where location of an igniter at a low elevation of a vessel resulting in a higher pressure rise upon initiation of a burn than for a similar experiment with an igniter at the top of the vessel due to its location with respect to the source of hydrogen.

Nevertheless, if it is assumed for conservatism that global burning cannot be precluded in the upper compartment, and the design of the hydrogen mitigation system must be based on this assumption, then the consequences of a global burn need to be considered. To analyze this situation, another look was taken using the CLASIX code on a situation wherein no hydrogen is burned in the upper plenum and a global burn occurs in the upper compartment. This analysis was originally reported

as case 5 in Section 4.0, using a flame speed of 2 feet/second. Recent work [4, 7] suggests that flame speeds of 8-12 feet/second are more likely, so the analysis was repeated using higher flame speeds. The following table summarizes those results:

Maximum Pressure (PSIG)	Burn Time (seconds)	Burn Velocity (feet/second)
14.4	55	2
28.4	13.75	8
40.8	5.5	20

The ASME Service Level C Capability of the McGuire containment is 45 PSIG. Therefore upper compartment global burns do not represent a threat to the integrity of the containment building even for unrealistically high burning velocities and ignition concentrations.

Of concern in the generation of large pressure rises in the upper compartment are the effects on the air return fans. These fans are not adversely affected by the differential pressure between upper and lower containment in the absence of upper compartment burning. If the higher differential pressures due to a global upper compartment burn occur, two effects must be assessed - fan structural integrity and fan operability. A structural analysis of the fan shows differential pressure capability in excess of 20 psid in the form of a static load. The equivalent static load on the fan is less than 20 psid for global burning. The impulse of angular momentum imparted to the fan by an upper compartment global burn will cause the fan to begin to drive the motor, turning the motor into an induction generator. This reversal of energy flow will prevent the fan speed from increasing more than a small amount above synchronous while the generator (motor) picks up system reactive load in

proportion to its speed increase. Current flow will reverse and the motor circuit breaker may trip on thermal overload (breaker type 90HFB, thermal overload size H81). The opening of the circuit breaker causes the motor to act as a brake on the fan and its speed will drop quickly. The status light in the control room will indicate to the operator that the fan is no longer running. There are two important points to make concerning the air return fan operability with respect to upper compartment burns:

1. A global burn at a concentration high enough to cause a problem with the fan will be a burn of a large amount of hydrogen. Our analysis of Case 5 shows that there is not sufficient hydrogen remaining in containment to be a threat to containment integrity, and the air return fan is no longer needed in the short term to promote containment mixing.

2. The air return fan and motor are not damaged by this temporary transient. Thermal overload sizes are based on the motor vendor's recommendation and will protect the motor from the effects of temporary over-current conditions. The control room operator may restart the fan by using the start switch following local reset of the circuit breaker thermal overloads. Thus the air return fan will be available within a short time and its long term operability is unaffected.

3. Based on the specific overload settings for the air return fan motors, and the short duration of adverse differential pressure on the fan, it is our judgement that the air return fan motor circuit breaker will not trip due to an upper compartment burn.

Based on the previous discussion, it may be concluded that location of the upper compartment igniters is not an important consideration in design of the Hydrogen Mitigation System. The present locations have been shown to be adequate, and better performance from alternative locations has been shown to be unlikely. However, to resolve the issue with the NRC Staff, four igniters will be added at a lower elevation in the upper containment. This location will be at approximately elevation 824' in the vicinity of an existing platform on top of the steam generator enclosures. At the top of the steam generator enclosures are concrete wing-like structures upon which the missile shields are placed during refueling. These concrete structures extend toward the centerline of the containment building from the crane wall and will therefore permit mounting the hydrogen igniters close to the compartment centerline. One igniter will be located on each of the four outboard concrete structures. The exact locations will be determined on the basis of providing access to the igniters for maintenance and testing but keeping them out of the way of the missile shield handling area. The new igniters will be placed so that one redundant pair is on each side of the containment, with the igniters located approximately 80° apart. These igniters will be powered from two new circuits from the emergency lighting system.

Additional Lower Compartment Igniters

NRC has proposed that two additional igniters be added to the lower compartment in the vicinity of the pressurizer relief tank at a low elevation. The justification for this change is based on the beneficial effects of ignition at the lower concentrations associated with upward propagation.

As presented in the general discussion section previously, we do not rely on global burns at higher concentrations to protect the containment. In our CLASIX analysis, we forced the containment response to be based on global burning to represent the worst case in terms of containment pressure and temperature response. We expect that our arrangement of igniters will result in a very large number of much smaller burns, initiated at concentrations of 5-7% in the vicinity of the igniters and propagated in all directions by the turbulent actions of the fan and jet mixing occurring in the lower containment. A substantial amount of the available hydrogen will be consumed in this manner because of the long period of time that these hydrogen conentrations will be available in the vicinity of the igniter and the available turbulent mixing which effectively refreshes the ignitable mixture in the vicinity of the igniters while promoting global propagation. Accordingly, no beneficial effect can be attributed to the addition of igniters at lower elevations in the lower compartment. However, to reolve this issue with the NRC Staff, two additional igniters will be added in the lower containment compartment. These two new igniters will be located at approximately elevation 730' in containment and outboard of the pressurizer relief tank. The exact location will have to be determined in the field and may vary slightly between units, depending on the available space. This elevation is below the midplane of the pressurizer relief tank and about five feet from the containment floor. Because these two igniters are below the post-LOCA flood level in containment, they will be wired to existing circuits which contain igniters below the post-LOCA flood level.

Indication of System Status

NRC has proposed that status indication for the hydrogen mitigation system be added to the control room. The justification for this change is the complexity in the manual initiation of the igniter system and the possible deenergization of this system by automatic action.

Duke agrees that this change should be made. We propose to add to the control room some type of indication system which will indicate when the igniters are energized. The type of indication will be determined after review by the Duke Control Room Design Review team.

REFERENCES

[1] Berman, Marshall, "Light Water Reactor Safety Research Program, Semiannual Report, April-September, 1981," NUREG/CR-2481, pp. 318-328.

[2] Kumar, R. K., H. Tamm, and W. C. Harrison, "Combustion Studies of Hydrogen-Air-Steam Mixtures in a Medium Size Containment Facility," AECL draft report to be published by EPRI.

[3] Hertzberg, Martin, "Flammability Limits and Pressure Development in H_2-Air Mixtures," PRC Report 4305, dated January, 1981, presented at the workshop on the Impact of Hydrogen on Water Reactor Safety, January 26-28, 1981.

[4] Seifert, K., R. Torok, and W. Wachtler, "Hydrogen Control Studies," Final Report, April 1982, to be published by EPRI.

[5] Tsai, S. S., "Fog Inerting Analysis for PWR Ice Condenser Plants," October, 1981.

[6] Zalosh, R. G., and S. N. Bajpai, "The Effect of Water Fogs on the Deliberate Ignition of Hydrogen," EPRI Report NP-2637, November, 1982.

[7] Private communication from P. G. Prassinos (Sandia) to Bob Palla (NRC), dated January 25, 1983.