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MEMORANDUM FOR: Steven A. Varga, Director
Division of Reactor Projects I/II

Jack W. Roe, Director
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& Quality Evaluation

FROM: Walter R. Butler, Director
Project Directorate I-2
Division of Reactor Projects I/II

William H. Regan, Jr., Chief
Human Factors Assessment Branch
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SUBJECT: TRIP REPORT RE: CONTAINMENT VENTING AT NINE MILE POINT 1 AND SUSQUEHANNA 1 & 2

A group of five staff members (W. R. Butler, M. C. Thadani, R. A. Benedict, J. P. Bongarra, and M. G. Evans) visited Nine Mile Point 1 (NMP-1) and Susquehanna 1 & 2 (SSES) on February 10, 1988 and February 11, 1988, respectively. As stated in an internal memorandum to you dated January 15, 1988, the object of the site visits was to review the venting emergency operating procedures (EOPs) at each site in conjunction with relevant P&IDs and plant walkdowns to determine whether there may exist any unique implementation problems or other matters that might warrant further NRR attention. The site visits were coordinated with the DEST staff (G. Thomas of SRXB), Region I (R. Blough and J. Johnson), and the Senior Resident Inspectors at both the sites. The results of the site visits are summarized here. A detailed report is enclosed for your information.

The selection of the two plants was based on the rationale that NMP-1 is an old plant and SSES is a relatively new plant. Additionally, NMP-1 has a BWR/2 reactor and Mark I containment, while SSES has a BWR/4 reactor and Mark II containment. The two selected plants, therefore, provided a good cross-section of the GE BWR facilities.

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The staff's Generic Letter 82-10, dated May 5, 1982, required all licensees for operating reactors to provide commitments for implementation of Post-TMI requirements summarized in NUREG-0737. Under Item I.C.1 of NUREG-0737 the licensees were required to revise EOPs by basing operator actions on symptoms rather than events. The BWR owners formed a group to respond to the requirements of NUREG-0737, Item I.C.1, and to develop generic Emergency Procedures Guidelines (EPGs) for BWR owners.

For emergency venting of the containments, the BWR owners group recommended the following in its Revision 2 and Revision 3 of the EPG.

> "If suppression chamber pressure exceeds the Primary Containment Pressure limit, vent the containment in accordance with the [procedures for containment venting] to reduce and maintain pressure below containment pressure limit."

The above guidance was approved by the staff in safety evaluations dated February 8, 1983, and November 28, 1983 respectively for EPG Revision 2 and Revision 3. EPG Revision 4 is presently under staff review.

The licensees have adopted the guidance of a range of EPG versions. The SSES has adopted EPG Revision 3 and NMP-1 has adopted EPG Revision 4.

Nine Mile Point 1 Inspection

The full power OL for NMP-1 was issued on August 22, 1969 to Niagara Mohawk Power Corporation (the licensee). The licensee was the architect engineer for NMP-1. The plant has some special features that have proved favorable to enhance its emergency venting capability. The special features include the following:

1. Torus and drywell vent lines of 24-inch diameter, which include a "hard pipe" from the torus/drywell isolation valves to the plant stack. These "hard pipes" bypass the Standby Gas Treatment System (SGTS) (low pressure vent leg).

2. Containment purge/vent isolation valves are qualified to operate in the LOCA environment. The outboard isolation valves can throttle the vent to the desired flow-rate and downstream pressure.

3. A 100-meter plant stack assures elevated vent gas releases to the environment.

4. A passive isolation condenser provides core cooling under station blackout events.

5. Radiation shielding of the isolation valves is provided by concrete floors and walls separating the drywell and torus.

A level 1 PRA for NMP-1 showed that initiating events contributing to core damage were dominated by transients (80%). The loss of offsite power contributed 11% to the core damage state. Based on the results of the PRA, the licensee has identified the loss of feedwater accompanied by failure to scram as the dominant accident sequence which has a scenario frequency of 3.2×10^{-4} per reactor year.

During our site visit, the licensee simulated the dominant scenario on the NMP-1 simulator and, using its venting procedures, showed how it can take advantage of the favorable plant design features discussed above to successfully recover from the transient. The containment protection was demonstrated by performing simulated emergency venting via the 24-inch hard pipe vent path to the plant stack. In this way the licensee's senior and experienced staff demonstrated successful recovery for a risk-dominant sequence using the containment venting EOP, including venting via the 24-inch torus vent line.

The staff believed that, technically, NMP-1 venting procedures will have a high degree of success in recovery from the plant-specific dominant sequences and high pressure venting can be successfully carried out without contaminating the reactor building or adversely affecting control room habitability.

However, a technical concern identified relates to the need (per EPG Revision 4 guidance) for operator decision to commence high pressure venting when containment pressure approaches 35 psig which is substantially below 62 psig containment design pressure. This is necessary because above this pressure the operability of the NMP-1 Allis-Chalmers containment isolation valves on the vent lines is not assured.

Our human factors review of the licensee's containment venting EOP and associated support procedures indicates that the current procedures cannot effectively support operators in venting during emergencies. The current EOP relies excessively on the operator's knowledge of venting steps for all identified pathways. There, currently, are no approved step-by-step instructions for venting actions. The licensee acknowledged that the current venting EOP and associated support procedures are not detailed enough for inexperienced operators to use effectively. The protection afforded by venting is complicated by the existence of eleven venting paths without any instructions on their use. The operations management simply would instruct the operator to perform venting at given containment pressure via a specified venting pathway without the benefit of the usual step-by-step instructions. Therefore, there is a distinct possibility that an inexperienced operator will inadvertently vent high pressure effluents via the SGTS pathway causing the sheet metal ducting to fail inside the secondary containment. However, this situation is presently being ameliorated and the licensee has prepared a new draft EOP revision, which the utility expects to have in place later this year. The new draft procedure for venting (discussed during the site visit, but not reviewed by the staff) contains the more detailed step-by-step instructions than do the current venting EOPs. However, the technical content and human factors adequacy of this revised procedure has not been assessed by the staff.

Susquehanna Steam Electric Station 1&2

The full power licenses for SSES were issued on July 17, 1982 for Unit 1, and March 23, 1984 for Unit 2. Each unit consists of a GE BWR/4 and a Mark II containment similar to the containments at LaSalle, Limerick, Shoreham and WNP-2.

Unlike NMP-1 the SSES at present does not have the requisite equipment for effective use of venting to mitigate over-pressure and hydrogen burn challenges to the containment for risk-dominant accident sequences. The SSES equipment may not survive if it were used to vent the containment at pressure greater than 15 psig. Although the plant has containment isolation valves (in the 24-inch drywell vent line and 18-inch torus vent line), which are qualified for design basis LOCA containment pressure and environment, the plumbing between these valves and the external vent release point is via the SGTS and consists of duct work which is unlikely to withstand pressure above 10 psig. Opening these valves during severe accidents when the containment may reach design pressures (53 psig) will certainly fail the duct work and release steam, hydrogen and fission products from the primary containment to the secondary containment. The fission product releases in the secondary containment could preclude access to essential safety equipment and complicate post-accident recovery efforts involving operator entry and/or use of equipment in the secondary containment. Moreover, the vent release to the atmosphere is located on the roof of the reactor building and any releases of noble gases via this vent path would behave like ground level releases outside the reactor building, if the ductwork survives the venting pressures. SSES purge and vent containment isolation valves' handwheels have been removed to prevent inadvertent manual operation via the handwheels. However, these air operated valves can be operated via manual local air connections.

The licensee has performed venting risk assessment studies using its inhouse individual plant evaluation (IPE) methodology which specifically simulates SSES plant systems. The venting study indicates that Station Blackout (SBO)

sequences dominate the core melt frequencies. Therefore, for venting to be meaningful under risk-dominant severe accidents, manual operation via local air connections to the containment isolation valves will be necessary. This can be achieved by relatively minor modifications to provide protection against severe radiation environments expected in the vicinity of these valves during severe accidents involving core damage (SSES valves are also separated from the suppression pool by a heavy concrete wall which provides some radiation shielding during venting).

The EOP dealing with containment venting has been in place at SSES since 1985, and is based on EPG (Revision 3) as approved by the staff's safety evaluation, dated October 18, 1983. The licensee has adopted the guidance literally, in that the existing normal operations vent procedure is used for emergencies following severe accidents. The normal vent path at SSES is routed through a two-inch line containing a one-inch valve orifice. This vent line will protect the downstream duct structure and SGTS from rupture, but will be ineffective in ameliorating the effects of dominant accident sequences where containment is challenged due to over-pressure. Because the 18-inch diameter torus lines are used in the "purge procedure," the licensee felt that by not choosing the 18-inch line for emergency venting, it was literally following the EPG (Revision 3) guidance to use normal vent paths for emergency venting. Therefore, the licensee did not feel that it was required by the EPG Revision 3 to harden the purge path to enable high vent flow rates of those severe accident sequences where containments are challenged due to overpressure. The use of the existing 18-inch diameter purge path was deemed not feasible for the reasons stated earlier. Thus the SSES does not at this time have an effective venting EOP in place to deal with risk-dominant severe accidents.

The licensee is fully aware of the above situation and is itself concerned about the problem. It has, therefore, instituted an intensive study of the subject of emergency venting. The licensee's study is based on its integrated risk reduction activity using its individual plant evaluation methodology to

assess benefits of alternative plant modifications which would provide effective containment protection in severe accident conditions. Present studies indicate that some equipment changes may be needed if useful venting EOPs utilizing 18-inch torus purge lines are to be implemented at SSES.

The current EOP and associated support procedures for venting generally conform to accepted human factors principles. However, the legibility of the EOP may require improvement to enable the operators to follow the procedures under poor lighting and accident conditions.

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Enclosure:
Supplementary Information

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Enclosure:
Supplementary Information

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Docket File	NRC PDR/LPDR
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SUPPLEMENTARY INFORMATION FOR TRIP REPORT ON
INSPECTION OF CONTAINMENT VENTING
PROCEDURES AT NINE MILE UNIT 1 AND SUSQUEHANNA UNITS 1&2

1.0 INTRODUCTION

Following the accident at TMI-2, the BWR Owners Group undertook development of Symptomatic Emergency Procedure Guidelines (EPGs). The EPGs have gone through an evolutionary process since TMI-2. As shown in Table 1, the EPG development started as operator guidance for small break LOCA (SBLOCA). Later, the BWR Owners Group developed symptomatic EPGs consistent with the requirements of item I.C.I of NUREG-0737. These guidelines addressed conditions beyond design basis accidents involving multiple failures. Revisions were made to the EPGs to incorporate new product lines (BWR/6) and to add guidelines for reactivity control, secondary containment control, and hydrogen control. Also, changes were made to reflect changes in equipment and new knowledge. The staff issued Safety Evaluation Reports for Revisions 2 and 3 on February 8, 1983 and November 28, 1983 respectively. In April 1987 the BWR Owners Group submitted EPG Rev. 4 which is still under staff review.

Guidance for emergency containment venting during serious pressure challenges to the containment following a severe accident was included in EPG Revisions 2 and 3. The guidance PC/P-7 states the following.

> "If suppression chamber pressure exceeds the Primary Containment Pressure Limit, vent the primary containment in accordance with [Procedures for containment venting] to reduce and maintain pressure below Primary Containment Pressure Limit."

TABLE 1: EPG DEVELOPMENT

THREE MILE ISLAND	MARCH, 1979
SBLOCA GUIDELINES	DECEMBER, 1979
FIRST SYMPTOMATIC EPG FOR BWR/1-5 (REV 0)	JUNE, 1980
EXTENDED TO INCLUDE BWR/6 (REV 1)	JANUARY, 1981
EXTENDED FOR REACTIVITY CONTROL (REV 2)	SEPTEMBER, 1982
EXTENDED TO SECONDARY CONTAINMENT (REV 3)	DECEMBER, 1982
EXTENDED FOR HYDROGEN CONTROL (REV 4)	APRIL, 1987

The licensees have diversely interpreted the above guidance and have implemented emergency operating procedures (EOPs) which vary from plant to plant depending upon the equipment availability and degree of understanding the objectives of the EPG guidance regarding venting in emergency circumstances. The implementation diversity is particularly significant for the sequences of events which lead to rapid high pressure challenges of the primary containments. The venting procedural requirements range from initiating venting at slightly below the design pressure (50-60 psig for Mark I and Mark II containments) to venting at 1.5 times the design pressure. The pathways chosen for venting are also diverse depending upon available hardware, since the licensees have been reluctant to make any significant plant modifications in the absence of any guidance to do so. Because of the diversity of venting pressures, pathways, and hardware availability, the staff concluded that some confirmation was needed as to whether the objectives of the emergency venting procedures have been met. The staff was, therefore, directed to review the venting EOPs and select some plants for inspection of the procedures and walkdown of the plant vent pathways. Accordingly, a group of staff members (W. R. Butler, M. C. Thadani, R. A. Benedict, J. P. Bongarra, and M. G. Evans) visited Nine Mile Point Unit 1 (NMP-1) and Susquehanna Steam Electric Station Units 1 and 2 (SSES) on February 10, 1988 and February 11, 1988 respectively, to review the venting EOPs to determine whether there exist any unique implementation problems or other matters that might warrant further NRR attention.

The staff's plan was to review the plant EOPs with the licensee and the Resident Inspector, review the sequences for which venting may be needed to maintain the containment integrity, to observe simulation of the same sequences on the plant specific simulator, to verify plant parameters at the time of venting, and finally to participate with the licensee in a walkdown of the EOPs and plant hardware to determine whether there exist any unique implementation problems or other matters that might warrant further staff attention.

2.0 EMERGENCY VENTING INSPECTIONS

2.1 Nine Mile Point Unit 1

The NMP-1 full power license was issued on August 22, 1969 to Niagara Mohawk Power Corporation (the licensee). The licensee was the Architect Engineer for the plant.

The NMP-1 consists of a GE BWR/2 product line reactor and a Mark I containment. The emergency cooling system consists of two trains. Each train provides a capability of natural circulation decay heat removal from the core at 100 seconds after the reactor scram, when reactor feedwater and main condenser capabilities are assumed to be lost.

Each of the two emergency cooling loops includes two condensers and an elevated makeup water storage with gravity feed to the condensers. Automatic operation of the emergency cooling system is initiated by high reactor pressure in excess of 1080 psig or low-low reactor water levels. Vents are provided at the high points in the steam lines to purge from the reactor vessel any noncondensable gases which may inhibit core cooling during natural circulation. Drains are provided at low points in the steam lines to eliminate condensate which might cause flashing/waterhammer at low pressures.

Primary containment is a GE Mark I configuration consisting of a light bulb-shaped drywell and a doughnut shaped suppression pool interconnected by downcomers which submerge in the suppression pool water. Vacuum breakers are provided in the interconnections between the drywell, the suppression pool, and the reactor building. The containment atmosphere is normally inerted with gaseous nitrogen to minimize the likelihood of combustion due to the potential for generation of large quantities of hydrogen from metal/water reactions during severe accidents. The containment is structurally designed to withstand a pressure of 62 psig

but could be expected to withstand higher pressure spikes for short durations. The plant has some features that have proved favorable to enhance emergency venting. The special features include the following:

1. Torus and drywell vent lines of 24-inch diameter, which include a "hard pipe" from the torus/drywell isolation valves to the plant stack. These "hard pipes" bypass the Standby Gas Treatment System (SGTS) low pressure vent leg and are capable of withstanding at least the containment design pressure.

2. Containment purge/vent isolation valves which are qualified to operate in the LOCA environment. The outboard isolation valves can throttle the vent to the desired flowrate and downstream pressure.

3. A 100-meter plant stack which assures elevated vent gas releases to the environment.

4. A passive isolation condenser which provides for core cooling under station blackout events.

5. Radiation shielding of the isolation valves is provided by concrete floors and walls separating the drywell and torus.

Emergency Operating Procedures for Venting

For NMP-1, the existing EOPs were prepared by Operations Engineering Incorporated, located in Fremont, California. In developing NMP-1 venting procedures, the licensee used EPG Revision 4 guidance. The current EOPs are not flowcharted and are in the form of minimal stepwise instructions to the operators supplemented by verbal instructions on which vent pathway to use. The EOPs have been reviewed and approved by Site Operations Review Committee. Basically, the present procedures

involve monitoring the containment hydrogen concentration and pressure. If the hydrogen concentration exceeds 3.2% or the drywell pressure cannot be controlled and exceeds drywell pressure limit, then the operator is required to vent the torus in accordance with the normal operating procedure N1-OP-9, Section G. The specific pathway to be used (there are 11 potential vent pathways) for venting is determined by Operations Management. The operator is then verbally instructed to vent the torus airspace along the pathway which would achieve pressure control with minimal fission product escape to the environment. The licensee indicated that its operators are highly trained and once they are told that a given vent flowrate and a pathway is to be used they will have no difficulty in achieving the required venting and establishing the containment pressure or hydrogen concentration control. A unique feature of the NMP Unit 1 purge and vent system is a 24-inch hard pipe designed for containment design pressure and capable of bypassing the standby gas treatment system, which could fail at a differential pressure greater than 0.5 psid. The NMP Unit 1 purge and vent valves are designed to operate at 35 psid. However, operability of the containment isolation valves at containment design pressure of 62 psig could not be verified. The licensee has promised to supply additional information on static and dynamic operability envelope of the containment isolation valves in the subsequent few days. NMP Unit 1 purge and vent valves can be throttled and can be used to regulate the vent flowrate and downstream pressure. This feature assures vent operation to match closely the containment pressure control requirements and downstream pressure limits if SGTS vent pathway is used.

As stated earlier, the procedures are not flowcharted and do not have the stepwise details which would minimize operator errors in executing the emergency venting procedures. For this reason, the licensee is presently developing a new emergency venting procedures Section 4.1 which will address but not be limited to all significant risk contributing severe accident scenarios for which torus venting will save the containment, and assure that the fission products are scrubbed in the suppression pool prior to venting. In this way the offsite exposures could be restricted to noble gases only and timing of venting could be flexible to assure

that the evacuation in the plume exposure pathway has been completed, and meteorological conditions are favorable to minimize the health effects due to offsite releases. A hard 24-inch vent pipe, which vents directly to the plant 100 meter stack, is already operational. Therefore, no significant plant modifications are anticipated at NMP Unit 1.

The new procedures are prescriptive in nature and include predecisions for venting and will have all the necessary details which do not require the operations management staff to verbally specify how venting will be conducted. In the new arrangement, the EOPs will specify when to vent and will lay out the objectives of venting. The Section 4.0 will refer the operator to the new proposed Section 4.1 which will have all the details of stepwise actions including details of jumpering procedures. The licensee is contemplating plant modifications which will eliminate the need for jumpering by providing signal bypass capability in the control room. The procedures will be modified to reflect these changes. The new procedures described above are in draft stage. They have not been approved or implemented by the licensee.

Risk Assessment Studies and Sequences for Venting

A level 1 PRA for NMP-1 showed that initiating events contributing to core damage were dominated by transients (80%). The loss of offsite power contributed 11% to the core damage state. Based on the results of the PRA, the licensee has identified the loss of feedwater accompanied by failure to scram as the dominant accident sequence which has a scenario frequency of 3.2 X 10^{-6} per reactor year.

During our site visit, the licensee simulated the dominant scenario on the NMP-1 simulator and, using its venting procedures, showed how it can take advantage of the favorable plant design features discussed above to successfully recover from the transient. The containment protection was demonstrated by performing simulated emergency venting procedures via the 24-inch hard pipe vent path to the plant stack. In this way the licensee demonstrated successful recovery for a risk dominant sequence using the simulated EOPs, including venting via the 24-inch torus vent line.

Training for Emergency Venting

All of the licensed operators are trained in the normal venting procedures. Emergency venting instructions will be given to the operators by senior operators. The instructions will give the operators specific identificaion of venting pathway, throttle flowrates, and downstream pressures to be controlled.

Human Factors Considerations

° From interviews with the licensee it was determined that:

1. The current EOPs in place are written from revision 4AC of the BWROG EPGs.

2. The current containment venting EOP is written as general guidance. The licensee believed that it could take credit for operator knowledge and experience and therefore did not prepare detailed instruction for venting containment in its upgraded EOPs. However, during operator requalification training, operators appeared confused when using the general level of guidance contained in the procedure. The licensee is presently in the process of revising the EOPs. The planned revision will be more detailed than the current procedure. The revision is anticipated to be completed before the plant restarts in April 1988. The licensee provided the staff with copies of a draft of the revised EOP during the interview. A human factors review of the draft revision was not performed.

° From the control room/plant walkdown:

1. A limited walkdown of the EOP and related procedures in the control room (the plant was in an outage and the control room was not readily accessible to the staff) identified that

operators could be expected to have difficulty using the current containment venting EOP concurrently with other required procedures because of the limited desk-top space available in the control room. This constraint was acknowledged by the licensee.

2. The walkdown also identified nomenclature inconsistencies between the EOP and the control room instrumentation (e.g., the operator is required by the EOP to determine if drywell temperature is below 212°F. The control room instrumentation is graduated such that the operator must estimate 212°F). The licensee acknowledged this finding and further indicated that in the current EOP there were other nomenclature inconsistencies with control room instrumentation. The licensee indicated that the revised EOP will address these instrument inconsistencies.

° From the desk top review of the EOP and associated procedures:

1. A limited desk top review of the licensee's plant-specific writer's guide for preparing EOPs, submitted as part of the licensee's Procedures Generation Package (PGP), indicated that the licensee had committed to preparing EOPs that were to be "consistent with the knowledge and capabilities of the least experienced intended user."

Based on the above observations, we conclude that, from the human factors considerations, the containment venting instructions contained in the EOP and associated operating procedures currently implemented by NMP-1 are not capable of effectively supporting operators in the mitigation of risk-dominant severe accident conditions which require venting the containment. This conclusion is further supported by the licensee's acknowledgement that the current instruction for venting does

not contain adequate detail for inexperienced operators to effectively use the instruction without receiving close supervision and supplementary direction from more experienced operators. In addition, in the current EOP and implementing procedure for containment venting (N1-OP-9, Section G.X), clear instruction is not provided to the operator for which vent path should be used under various plant conditions.

Therefore, it is possible that operators, especially those less experienced and under the stress of an emergency, might select the vent path most familiar to them (i.e., the path that would be used to vent under normal operating conditions). If the normal vent path was chosen to vent containment under emergency conditions, the potential exists that ductwork and filters which comprise part of the vent path for the SGTS would fail and that the reactor and turbine buildings could be exposed to excessive levels of radioactivity.

<u>Walkdown of Venting Systems and Equipment Called Out in Emergency Venting Procedures</u>

The staff walked down the NMP Unit 1 purge and vent pathways and observed the following.

1. The purge and vent piping is 24" diameter hard piped from drywell and torus to a common 24" pipe exhausting into a 100 meter plant stack. This pathway can bypass the SGTS.

2. The SGTS filters might blow out at pressure differences greater than 0.5 psid. If filter train pathway is used for high pressure venting, then the steam and/or fission product could be released to the reactor building.

3. The large purge/vent containment isolation valves are fitted with handwheels and are easily accessible for local manual operation. The valves are shielded from potential high radiation areas by concrete floors and walls (shielding adequacy is not known).

2.3 Susquehanna Units 1 and 2

The plant consists of twin units of GE BWR/4 with Mark II containment. Each unit has a nominal rated power of 1100 MWe. The plant's Emergency Core Cooling System consists of 2 loops of Core Spray System, one loop of High Pressure Coolant Injection System, Automatic Depressurization System of 6 relief valves, and 2 loops of Low Pressure Coolant Injection System. Other auxiliary systems include 2 loops of residual heat removal system and a Reactor Core Isolation Cooling System. The plant's Mark II containment consists of a drywell and a suppression pool connected via downcomers. Vacuum breakers are provided in the interconnections between drywell, suppression pool and reactor building.

Emergency Venting Procedures

The licensee has implemented the guidance contained in EPG Revision 3. The procedures have been written to literally follow the guidance which states that the licensee should provide for containment venting at design pressure and via the existing vent paths. The licensee has indicated that its existing vent path is a 2-inch line with 1-inch valve orifice designed to bypass the main 18-inch purge valves in the torus purge system. The reason for not using the 18-inch purge line is that it runs into a low pressure circular duct and passes through SGTS, which is not designed to accommodate pressure greater than 10 psig. The licensee stated that by adopting the small bypass venting line it has followed the guidance literally but has not met the intent of venting at design pressure (since the 2-inch bypass vent line is totally inadequate even for the minimum required rates of steam flow associated with dissipation of decay heat following reactor shutdown).

The current EOP for venting states that the operators must initiate venting procedures if the containment pressure exceeds 53 psig. The venting should be performed via the suppression pool unless the pool water level is above 38 feet. The alternate vent path is via the drywell.

The venting must be terminated if the pressure in the suppression pool or the drywell falls below 45 psig. The EOPs then direct the operator to normal operating procedure ON-134-001 which provides a detailed and stepwise guidance on venting procedures, using OP-173-001 Section 3.4 for drywell venting, and Section 3.5 for suppression pool venting. Figure 1 shows the Susquehanna containment. The drywell venting is conducted via 24-inch valve HV-15713 and 2-inch bypass valve HV-15711, keeping the second 24-inch isolation valve HV-15714 closed. The vent path then proceeds through sheet metal ducting and SGTS filter trains as shown in Figure 2. For suppression pool venting the operators will open 18-inch containment isolation valve HV-15703 and 2-inch bypass line valve HV-15705, keeping HV-15704 closed. The vent path beyond the 2-inch bypass line is via sheet metal 18-inch duct which joins the duct from the drywell purge line and proceeds via the SGTS. The ultimate release point of the vent is the top of the reactor building. There is no tall stack at Susquehanna for elevated releases of gaseous effluents.

As stated earlier the licensee is not satisfied with the emergency venting procedures, but has adopted them merely to comply with the NRC approved EPG Revision 3. These procedures have been in place since middle of 1985. The licensee stated that it did not have time to develop other venting designs which, in its opinion, would be very complex and operator action intensive. The licensee has, however, developed other venting concepts which would involve plant modifications consisting of 18-inch hard pipe (bypassing sheet metal ducts and SGTS), having a rupture disk downstream of a new 18-inch remote DC operated valve which can be opened and closed from a remote location as required. No EOPs have been drafted for larger vent paths at this time.

Risk Assessment Studies and Venting Sequences

The licensee is a participant in the Industry Degraded Core Rulemaking (IDCOR) group demonstration program for Individual Plant Examination (IPE) methodology validation for BWR 4/Mark II plant. Its risk

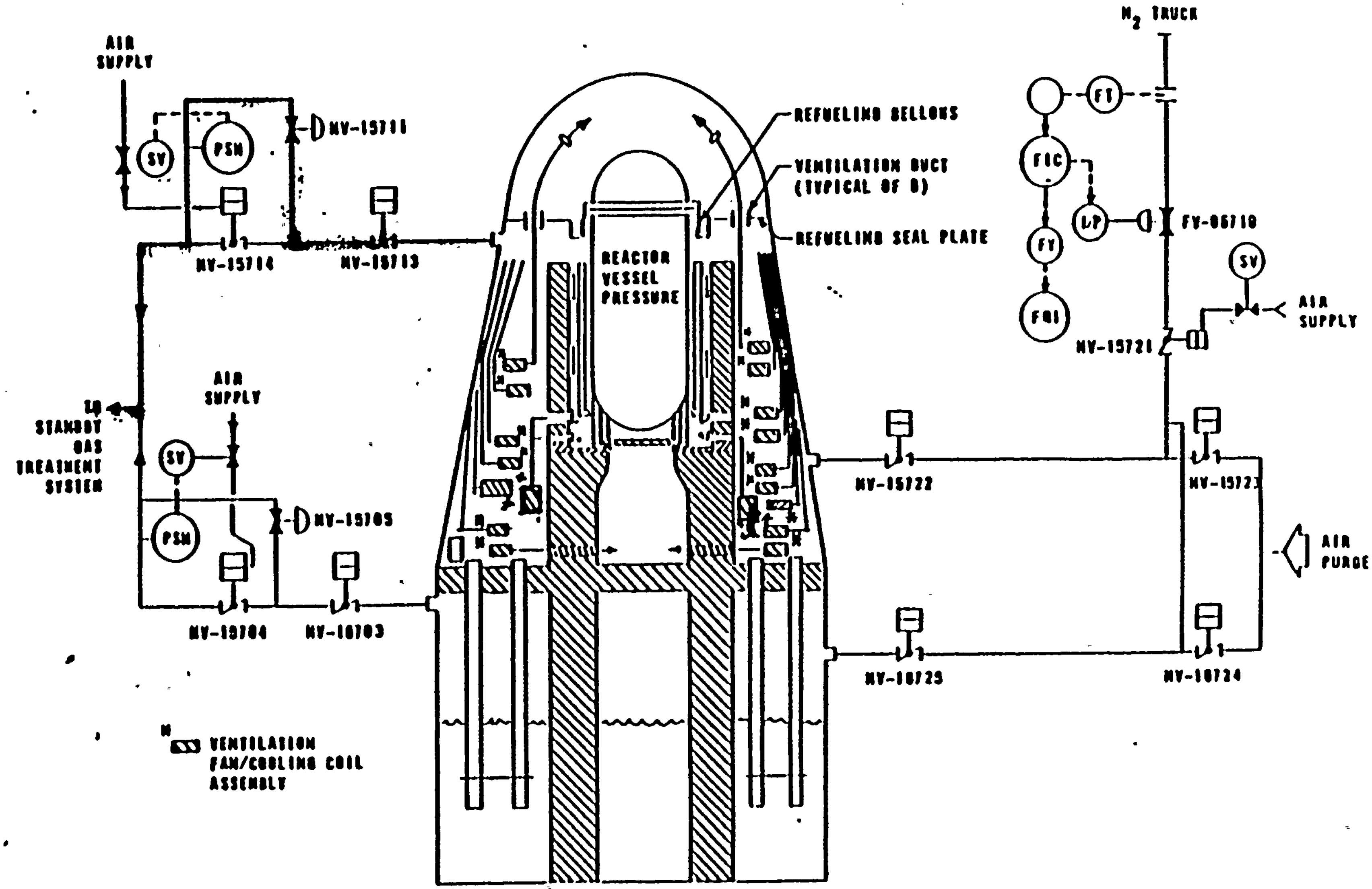

FIGURE 1

SIMPLIFIED DIAGRAM

CONTAINMENT PURGE, COOLING, AND VENTILATION

SUSQUEHANNA STEAM ELECTRIC STATION

UNITS 1 AND 2

Attachment 4
pg 1 of 2

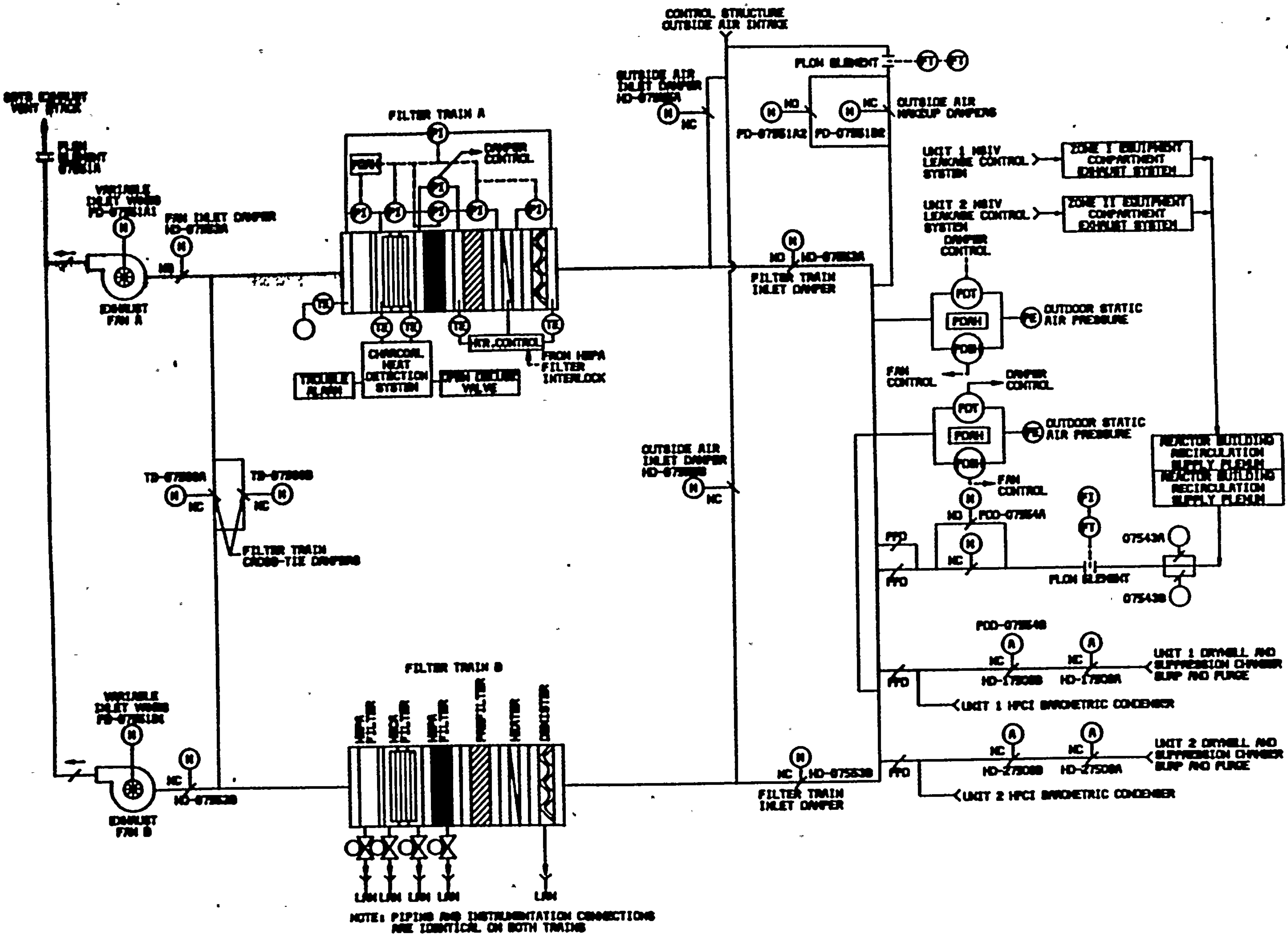

FIGURE 2
STANDBY GAS TREATMENT SYSTEM
LOCA INITIATED—

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2

A 400 SHT. 336 REV. 3 DATE 10/9/85

Attachment T
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assessment studies performed for the SSES show station blackout sequences dominate the core melt risk spectrum. Therefore, for venting to be effective under severe accident conditions, manual operation (via local air connections of the containment isolation valves) will be necessary. This can be achieved by relatively minor modifications to provide protection against severe radiation environments expected in the vicinity of these valves during severe accidents involving core damage.

Based on its IPE analyses, the licensee has identified the following five sequences for its venting studies.

1. Loss of main condenser, suppression pool cooling, and RWCU Blowdown.

2. LOCA with loss of suppression pool cooling

3. Station blackout and no ac recovery for longer than 24 hours

4. Station blackout with failure of HPCI and RCIC start.

5. ATWS with loss of bypass and failure of SLCS.

Based on its venting study, the licensee's staff has concluded the following:

1. Provision of (hard pipe) vent capability in combination with back up generators will give indefinite Station Blackout coping capability

2. Wetwell venting is probably required to meet the licensee's fundamental policy of providing defense-in-depth using all available hardware.

3. Existing equipment with some modification can meet most requirements and concerns but may require testing of vent path integrity.

4. The current licensee evaluations are directed to provide sufficient information for the licensee management to make a decision on a venting approach and justification for its adequacy.

Venting Consequences

The licensee has evaluated the consequences of venting with the existing equipment. The licensee concludes that high pressure venting (greater than 15 psig which could result in soft ducting pressure to exceed 10 psig) will fail the existing ductwork in the reactor building. For core damage sequences the radiation levels will be high and will prevent operator entry into the reactor building to take any remedial actions. The control room ventilation system will have to be placed in recirculation mode. Some airborne radiation may leak into the control room.

The licensee studies for future concepts show that addition of a hard pipe vent system will assure low radiation levels in the reactor building. The control room ventilation system will need to be placed in recirculation mode of operation to assure that the vented fission products do not contaminate the control room atmosphere. Venting strategy will have to assure that evacuation from the plume exposure pathway has been completed and meteorological conditions are favorable for venting. The licensee will perform an integrated risk reduction study to evaluate the feasibility of future venting concepts.

Human Factors Considerations

From the desk-top review and walkdown the staff has determined the following:

1. A limited review of the EOP and the associated documentation for Primary Containment Control and the station procedures for containment venting, indicated that they generally incorporated accepted human factors practices for preparing procedures. The licensee's EOPs are in a large-scale flowchart format, with the procedures comprising 11 laminated boards. The EOPs appeared to be

easily identifiable, and conveniently located in the control room. Ample space was available for operators to effectively use them in the control room. The licensee has revised the EOPs using a low gloss laminate to eliminate the glare produced by previous versions of the EOPs. Though the EOPs appear to incorporate accepted human factors principles and enhancements (e.g., place keeping aids; some color coding), we are concerned that operators might have some difficulty in reading the procedural steps especially under low level lighting conditions, because of the small type size and overall small size of the flowchart symbols.

For example, though not directly related to the specific step in the EOP for venting containment, there are decision statements in the primary containment control EOP that have the "yes/no" logic paths reversed, i.e., some statements require a "yes" decision to follow a "right-hand" flow path in the EOP; others require the "yes" decision to follow a "left-hand" flow path. The combination of this type of inconsistency with the small type face and symbol size used in the flowcharts may cause operators to make potentially safety-significant errors using the EOP in emergency conditions. In addition to the flowchart EOPs, the licensee has, for each EOP step, a basis document. The basis document contains the EOP step, in conventional narrative format, a reference for each step to the plant-specific technical guideline and the associated EPG step and an explanation of the purpose for performing the step. The basis documents are located in the control room, available to the operators and are also used during training. The licensee uses a "reader-doer" concept for implementing the EOPs, with an SRO using the flowcharts to direct the actions of ROs at the control boards.

2. The staff was unable to exercise the EOP and related venting procedures in the simulator because an operating crew was not available. Without exercising the EOPs and associated procedures, it is difficult to conclude that the operators would be able to effectively perform their required actions under stressful conditions.

3. During the plant walkdown, the staff observed the location of several components that would be activated during containment venting. When asked if an air-operated valve (HV-15703) in the SGTS could be operated, if required under accident conditions, the licensee indicated that there is a possibility that this particular valve might become inaccessible to operators because of the potential for high levels of radiation existing in the vicinity of the valve (it is near the drywell) during some emergency conditions.

4. The licensee indicated that it has a human factors professional on the staff who is involved in the review of the EOP covering containment venting and in procedures development and revision efforts.

Based on the above observations, we conclude that the containment venting instructions contained in the EOP and associated operating procedures currently implemented by Susquehanna do not technically support venting the containment under emergency conditions. This conclusion is acknowledged by the licensee. The current EOP instruction and associated procedures generally conform to accepted human factors principles. However, some reservation exists whether or not they can be effectively and reliably implemented under emergency conditions because of the poor legibility of the EOP and because of the possible inability of operators to perform manual control manipulations, in the plant, under certain emergency conditions.

Walkdown of Venting Systems and Equipment Called Out in Emergency Venting Procedures

Unlike NMP-1 the SSES at present does not have much of the equipment needed for effective use of venting to mitigate over-pressure and hydrogen burn challenges to the containment for those accident sequences when the containment pressure is likely to be high (greater than 20 psig). Although the plant has containment isolation valves (in the 24 inch drywell vent line and 18 inch torus vent line), which are qualified for design basis LOCA containment pressure and environment, the plumbing between these valves and the external vent release point is via the SGTS and consists of duct work which is unlikely to withstand pressure above 10 psig. Opening these valves during severe accidents, when the containment may reach design pressure (53 psig), will certainly fail the duct work and release steam, hydrogen and noble gases from the primary containment to the reactor building (secondary containment). The releases in the secondary containment may preclude availability of some unfailed safety equipment and complicate post-accident recovery efforts involving operator entry to use that equipment. Moreover, the vent release to the atmosphere is located on the roof of the reactor building and any releases of noble gases via this vent path would behave like ground level releases outside the reactor building, if the duct work survives the venting pressures. SSES purge and vent containment isolation valves' handwheels have been removed to prevent inadvertent manual operation. However, these air operated valves can be operated via manual local air connections. The venting study indicates that Station Blackout (SBO) sequences dominate the core melt frequencies. Therefore, for venting to be effective under risk-dominant accidents, manual operation via local air connections of the containment isolation valves will be necessary. This can be achieved by relatively minor modifications to provide protection against severe radiation environments expected in the vicinity of these valves during severe accidents involving core damage (SSES valves are also separated from the suppression pool by a heavy concrete wall).

3.0 CONCLUSIONS

The staff's inspection confirmed that there is a wide diversity of plant-specific venting EOPs.

There are significant variations in the designs of the containments and the safety systems. At some plants the venting can be implemented with the current hardware. At other plants substantial modifications will be needed to achieve the objectives of venting in a safe manner.

For those plants where SBO sequences are dominant and where the vent paths are routed via soft piping, hard pipe modifications would be needed for deriving maximum benefit of emergency venting.

For plants which do not have tall (100 meters) stacks, release of fission products via the vent path may require modifications to prevent fission products infiltration into the control room.

At NMP-1, the venting can safely mitigate the consequences of the dominant accident sequences. The present containment venting and associated support procedures at NMP-1 do not provide the necessary details to prevent operator errors. The revision under preparation will contain greater instructional detail.

At SSES, SBO sequences dominate the risk and venting is routed via soft pipe paths. The licensee has therefore adopted venting via 2-inch line with 1-inch valve orifice to assure low downstream pressure. While this arrangement may prevent failure of soft pipes downstream of the 1-inch orifice, it also prevents adequate vent flowrate to deal with expected severe accident challenges of containment over-pressurization. Though the licensee's procedures appeared to incorporate accepted human factors practices, the overall small size of the EOP text and symbols may detract from the effectiveness of these procedures under emergency conditions.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

March 16, 1988

MEMORANDUM FOR: Steven A. Varga, Director
Division of Reactor Projects I/II

Jack W. Roe, Director
Division of Licensee Performance
& Quality Evaluation

FROM: Walter R. Butler, Director
Project Directorate I-2
Division of Reactor Projects I/II

William H. Regan, Jr., Chief
Human Factors Assessment Branch
Division of Licensee Performance
and Quality Evaluation

SUBJECT: TRIP REPORT RE: CONTAINMENT VENTING AT NINE MILE POINT 1 AND SUSQUEHANNA 1 & 2

A group of five staff members (W. R. Butler, M. C. Thadani, R. A. Benedict, J. P. Bongarra, and M. G. Evans) visited Nine Mile Point 1 (NMP-1) and Susquehanna 1 & 2 (SSES) on February 10, 1988 and February 11, 1988, respectively. As stated in an internal memorandum to you dated January 15, 1988, the object of the site visits was to review the venting emergency operating procedures (EOPs) at each site in conjunction with relevant P&IDs and plant walkdowns to determine whether there may exist any unique implementation problems or other matters that might warrant further NRR attention. The site visits were coordinated with the DEST staff (G. Thomas of SRXB), Region I (R. Blough and J. Johnson), and the Senior Resident Inspectors at both the sites. The results of the site visits are summarized here. A detailed report is enclosed for your information.

The selection of the two plants was based on the rationale that NMP-1 is an old plant and SSES is a relatively new plant. Additionally, NMP-1 has a BWR/2 reactor and Mark I containment, while SSES has a BWR/4 reactor and Mark II containment. The two selected plants, therefore, provided a good cross-section of the GE BWR facilities.

Contact: M. C. Thadani
X21427

The staff's Generic Letter 82-10, dated May 5, 1982, required all licensees for operating reactors to provide commitments for implementation of Post-TMI requirements summarized in NUREG-0737. Under Item I.C.1 of NUREG-0737 the licensees were required to revise EOPs by basing operator actions on symptoms rather than events. The BWR owners formed a group to respond to the requirements of NUREG-0737, Item I.C.1, and to develop generic Emergency Procedures Guidelines (EPGs) for BWR owners.

For emergency venting of the containments, the BWR owners group recommended the following in its Revision 2 and Revision 3 of the EPG.

> "If suppression chamber pressure exceeds the Primary Containment Pressure limit, vent the containment in accordance with the [procedures for containment venting] to reduce and maintain pressure below containment pressure limit."

The above guidance was approved by the staff in safety evaluations dated February 8, 1983, and November 28, 1983 respectively for EPG Revision 2 and Revision 3. EPG Revision 4 is presently under staff review.

The licensees have adopted the guidance of a range of EPG versions. The SSES has adopted EPG Revision 3 and NMP-1 has adopted EPG Revision 4.

<u>Nine Mile Point 1 Inspection</u>

The full power OL for NMP-1 was issued on August 22, 1969 to Niagara Mohawk Power Corporation (the licensee). The licensee was the architect engineer for NMP-1. The plant has some special features that have proved favorable to enhance its emergency venting capability. The special features include the following:

1. Torus and drywell vent lines of 24-inch diameter, which include a "hard pipe" from the torus/drywell isolation valves to the plant stack. These "hard pipes" bypass the Standby Gas Treatment System (SGTS) (low pressure vent leg).

2. Containment purge/vent isolation valves are qualified to operate in the LOCA environment. The outboard isolation valves can throttle the vent to the desired flow-rate and downstream pressure.

3. A 100-meter plant stack assures elevated vent gas releases to the environment.

4. A passive isolation condenser provides core cooling under station blackout events.

5. Radiation shielding of the isolation valves is provided by concrete floors and walls separating the drywell and torus.

A level 1 PRA for NMP-1 showed that initiating events contributing to core damage were dominated by transients (80%). The loss of offsite power contributed 11% to the core damage state. Based on the results of the PRA, the licensee has identified the loss of feedwater accompanied by failure to scram as the dominant accident sequence which has a scenario frequency of 3.2×10^{-4} per reactor year.

During our site visit, the licensee simulated the dominant scenario on the NMP-1 simulator and, using its venting procedures, showed how it can take advantage of the favorable plant design features discussed above to successfully recover from the transient. The containment protection was demonstrated by performing simulated emergency venting via the 24-inch hard pipe vent path to the plant stack. In this way the licensee's senior and experienced staff demonstrated successful recovery for a risk-dominant sequence using the containment venting EOP, including venting via the 24-inch torus vent line.

The staff believed that, technically, NMP-1 venting procedures will have a high degree of success in recovery from the plant-specific dominant sequences and high pressure venting can be successfully carried out without contaminating the reactor building or adversely affecting control room habitability.

However, a technical concern identified relates to the need (per EPG Revision 4 guidance) for operator decision to commence high pressure venting when containment pressure approaches 35 psig which is substantially below 62 psig containment design pressure. This is necessary because above this pressure the operability of the NMP-1 Allis-Chalmers containment isolation valves on the vent lines is not assured.

Our human factors review of the licensee's containment venting EOP and associated support procedures indicates that the current procedures cannot effectively support operators in venting during emergencies. The current EOP relies excessively on the operator's knowledge of venting steps for all identified pathways. There, currently, are no approved step-by-step instructions for venting actions. The licensee acknowledged that the current venting EOP and associated support procedures are not detailed enough for inexperienced operators to use effectively. The protection afforded by venting is complicated by the existence of eleven venting paths without any instructions on their use. The operations management simply would instruct the operator to perform venting at given containment pressure via a specified venting pathway without the benefit of the usual step-by-step instructions. Therefore, there is a distinct possibility that an inexperienced operator will inadvertently vent high pressure effluents via the SGTS pathway causing the sheet metal ducting to fail inside the secondary containment. However, this situation is presently being ameliorated and the licensee has prepared a new draft EOP revision, which the utility expects to have in place later this year. The new draft procedure for venting (discussed during the site visit, but not reviewed by the staff) contains the more detailed step-by-step instructions than do the current venting EOPs. However, the technical content and human factors adequacy of this revised procedure has not been assessed by the staff.

Susquehanna Steam Electric Station 1&2

The full power licenses for SSES were issued on July 17, 1982 for Unit 1, and March 23, 1984 for Unit 2. Each unit consists of a GE BWR/4 and a Mark II containment similar to the containments at LaSalle, Limerick, Shoreham and WNP-2.

Unlike NMP-1 the SSES at present does not have the requisite equipment for effective use of venting to mitigate over-pressure and hydrogen burn challenges to the containment for risk-dominant accident sequences. The SSES equipment may not survive if it were used to vent the containment at pressure greater than 15 psig. Although the plant has containment isolation valves (in the 24-inch drywell vent line and 18-inch torus vent line), which are qualified for design basis LOCA containment pressure and environment, the plumbing between these valves and the external vent release point is via the SGTS and consists of duct work which is unlikely to withstand pressure above 10 psig. Opening these valves during severe accidents when the containment may reach design pressures (53 psig) will certainly fail the duct work and release steam, hydrogen and fission products from the primary containment to the secondary containment. The fission product releases in the secondary containment could preclude access to essential safety equipment and complicate post-accident recovery efforts involving operator entry and/or use of equipment in the secondary containment. Moreover, the vent release to the atmosphere is located on the roof of the reactor building and any releases of noble gases via this vent path would behave like ground level releases outside the reactor building, if the ductwork survives the venting pressures. SSES purge and vent containment isolation valves' handwheels have been removed to prevent inadvertent manual operation via the handwheels. However, these air operated valves can be operated via manual local air connections.

The licensee has performed venting risk assessment studies using its inhouse individual plant evaluation (IPE) methodology which specifically simulates SSES plant systems. The venting study indicates that Station Blackout (SBO)

sequences dominate the core melt frequencies. Therefore, for venting to be meaningful under risk-dominant severe accidents, manual operation via local air connections to the containment isolation valves will be necessary. This can be achieved by relatively minor modifications to provide protection against severe radiation environments expected in the vicinity of these valves during severe accidents involving core damage (SSES valves are also separated from the suppression pool by a heavy concrete wall which provides some radiation shielding during venting).

The EOP dealing with containment venting has been in place at SSES since 1985, and is based on EPG (Revision 3) as approved by the staff's safety evaluation, dated October 18, 1983. The licensee has adopted the guidance literally, in that the existing normal operations vent procedure is used for emergencies following severe accidents. The normal vent path at SSES is routed through a two-inch line containing a one-inch valve orifice. This vent line will protect the downstream duct structure and SGTS from rupture, but will be ineffective in ameliorating the effects of dominant accident sequences where containment is challenged due to over-pressure. Because the 18-inch diameter torus lines are used in the "purge procedure," the licensee felt that by not choosing the 18-inch line for emergency venting, it was literally following the EPG (Revision 3) guidance to use normal vent paths for emergency venting. Therefore, the licensee did not feel that it was required by the EPG Revision 3 to harden the purge path to enable high vent flow rates of those severe accident sequences where containments are challenged due to overpressure. The use of the existing 18-inch diameter purge path was deemed not feasible for the reasons stated earlier. Thus the SSES does not at this time have an effective venting EOP in place to deal with risk-dominant severe accidents.

The licensee is fully aware of the above situation and is itself concerned about the problem. It has, therefore, instituted an intensive study of the subject of emergency venting. The licensee's study is based on its integrated risk reduction activity using its individual plant evaluation methodology to

assess benefits of alternative plant modifications which would provide effective containment protection in severe accident conditions. Present studies indicate that some equipment changes may be needed if useful venting EOPs utilizing 18-inch torus purge lines are to be implemented at SSES.

The current EOP and associated support procedures for venting generally conform to accepted human factors principles. However, the legibility of the EOP may require improvement to enable the operators to follow the procedures under poor lighting and accident conditions.

/s/

William H. Regan, Jr., Chief
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Division of Licensee Performance
and Quality Evaluation

/s/

Walter R. Butler, Director
Project Directorate I-2
Division of Reactor Projects I/II

Enclosure:
Supplementary Information

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Docket File	NRC PDR/LPDR
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Docket NOS. 50-387/388
50-220

Previously concurred*

PDI-2/PM*	PDI-2/D*	PDI-1/PM	PDI-1/D	HFAB/DLPQ
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Enclosure:
Supplementary Information

SUPPLEMENTARY INFORMATION FOR TRIP REPORT ON
INSPECTION OF CONTAINMENT VENTING
PROCEDURES AT NINE MILE UNIT 1 AND SUSQUEHANNA UNITS 1&2

1.0 INTRODUCTION

Following the accident at TMI-2, the BWR Owners Group undertook development of Symptomatic Emergency Procedure Guidelines (EPGs). The EPGs have gone through an evolutionary process since TMI-2. As shown in Table 1, the EPG development started as operator guidance for small break LOCA (SBLOCA). Later, the BWR Owners Group developed symptomatic EPGs consistent with the requirements of item I.C.I of NUREG-0737. These guidelines addressed conditions beyond design basis accidents involving multiple failures. Revisions were made to the EPGs to incorporate new product lines (BWR/6) and to add guidelines for reactivity control, secondary containment control, and hydrogen control. Also, changes were made to reflect changes in equipment and new knowledge. The staff issued Safety Evaluation Reports for Revisions 2 and 3 on February 8, 1983 and November 28, 1983 respectively. In April 1987 the BWR Owners Group submitted EPG Rev. 4 which is still under staff review.

Guidance for emergency containment venting during serious pressure challenges to the containment following a severe accident was included in EPG Revisions 2 and 3. The guidance PC/P-7 states the following.

> "If suppression chamber pressure exceeds the Primary Containment Pressure Limit, vent the primary containment in accordance with [Procedures for containment venting] to reduce and maintain pressure below Primary Containment Pressure Limit."

TABLE 1: EPG DEVELOPMENT

THREE MILE ISLAND	MARCH, 1979
SBLOCA GUIDELINES	DECEMBER, 1979
FIRST SYMPTOMATIC EPG FOR BWR/1-5 (REV 0)	JUNE, 1980
EXTENDED TO INCLUDE BWR/6 (REV 1)	JANUARY, 1981
EXTENDED FOR REACTIVITY CONTROL (REV 2)	SEPTEMBER, 1982
EXTENDED TO SECONDARY CONTAINMENT (REV 3)	DECEMBER, 1982
EXTENDED FOR HYDROGEN CONTROL (REV 4)	APRIL, 1987

The licensees have diversely interpreted the above guidance and have implemented emergency operating procedures (EOPs) which vary from plant to plant depending upon the equipment availability and degree of understanding the objectives of the EPG guidance regarding venting in emergency circumstances. The implementation diversity is particularly significant for the sequences of events which lead to rapid high pressure challenges of the primary containments. The venting procedural requirements range from initiating venting at slightly below the design pressure (50-60 psig for Mark I and Mark II containments) to venting at 1.5 times the design pressure. The pathways chosen for venting are also diverse depending upon available hardware, since the licensees have been reluctant to make any significant plant modifications in the absence of any guidance to do so. Because of the diversity of venting pressures, pathways, and hardware availability, the staff concluded that some confirmation was needed as to whether the objectives of the emergency venting procedures have been met. The staff was, therefore, directed to review the venting EOPs and select some plants for inspection of the procedures and walkdown of the plant vent pathways. Accordingly, a group of staff members (W. R. Butler, M. C. Thadani, R. A. Benedict, J. P. Bongarra, and M. G. Evans) visited Nine Mile Point Unit 1 (NMP-1) and Susquehanna Steam Electric Station Units 1 and 2 (SSES) on February 10, 1988 and February 11, 1988 respectively, to review the venting EOPs to determine whether there exist any unique implementation problems or other matters that might warrant further NRR attention.

The staff's plan was to review the plant EOPs with the licensee and the Resident Inspector, review the sequences for which venting may be needed to maintain the containment integrity, to observe simulation of the same sequences on the plant specific simulator, to verify plant parameters at the time of venting, and finally to participate with the licensee in a walkdown of the EOPs and plant hardware to determine whether there exist any unique implementation problems or other matters that might warrant further staff attention.

2.0 EMERGENCY VENTING INSPECTIONS

2.1 Nine Mile Point Unit 1

The NMP-1 full power license was issued on August 22, 1969 to Niagara Mohawk Power Corporation (the licensee). The licensee was the Architect Engineer for the plant.

The NMP-1 consists of a GE BWR/2 product line reactor and a Mark I containment. The emergency cooling system consists of two trains. Each train provides a capability of natural circulation decay heat removal from the core at 100 seconds after the reactor scram, when reactor feedwater and main condenser capabilities are assumed to be lost.

Each of the two emergency cooling loops includes two condensers and an elevated makeup water storage with gravity feed to the condensers. Automatic operation of the emergency cooling system is initiated by high reactor pressure in excess of 1080 psig or low-low reactor water levels. Vents are provided at the high points in the steam lines to purge from the reactor vessel any noncondensable gases which may inhibit core cooling during natural circulation. Drains are provided at low points in the steam lines to eliminate condensate which might cause flashing/waterhammer at low pressures.

Primary containment is a GE Mark I configuration consisting of a light bulb-shaped drywell and a doughnut shaped suppression pool interconnected by downcomers which submerge in the suppression pool water. Vacuum breakers are provided in the interconnections between the drywell, the suppression pool, and the reactor building. The containment atmosphere is normally inerted with gaseous nitrogen to minimize the likelihood of combustion due to the potential for generation of large quantities of hydrogen from metal/water reactions during severe accidents. The containment is structurally designed to withstand a pressure of 62 psig

but could be expected to withstand higher pressure spikes for short durations. The plant has some features that have proved favorable to enhance emergency venting. The special features include the following:

1. Torus and drywell vent lines of 24-inch diameter, which include a "hard pipe" from the torus/drywell isolation valves to the plant stack. These "hard pipes" bypass the Standby Gas Treatment System (SGTS) low pressure vent leg and are capable of withstanding at least the containment design pressure.

2. Containment purge/vent isolation valves which are qualified to operate in the LOCA environment. The outboard isolation valves can throttle the vent to the desired flowrate and downstream pressure.

3. A 100-meter plant stack which assures elevated vent gas releases to the environment.

4. A passive isolation condenser which provides for core cooling under station blackout events.

5. Radiation shielding of the isolation valves is provided by concrete floors and walls separating the drywell and torus.

Emergency Operating Procedures for Venting

For NMP-1, the existing EOPs were prepared by Operations Engineering Incorporated, located in Fremont, California. In developing NMP-1 venting procedures, the licensee used EPG Revision 4 guidance. The current EOPs are not flowcharted and are in the form of minimal stepwise instructions to the operators supplemented by verbal instructions on which vent pathway to use. The EOPs have been reviewed and approved by Site Operations Review Committee. Basically, the present procedures

involve monitoring the containment hydrogen concentration and pressure. If the hydrogen concentration exceeds 3.2% or the drywell pressure cannot be controlled and exceeds drywell pressure limit, then the operator is required to vent the torus in accordance with the normal operating procedure N1-OP-9, Section G. The specific pathway to be used (there are 11 potential vent pathways) for venting is determined by Operations Management. The operator is then verbally instructed to vent the torus airspace along the pathway which would achieve pressure control with minimal fission product escape to the environment. The licensee indicated that its operators are highly trained and once they are told that a given vent flowrate and a pathway is to be used they will have no difficulty in achieving the required venting and establishing the containment pressure or hydrogen concentration control. A unique feature of the NMP Unit 1 purge and vent system is a 24-inch hard pipe designed for containment design pressure and capable of bypassing the standby gas treatment system, which could fail at a differential pressure greater than 0.5 psid. The NMP Unit 1 purge and vent valves are designed to operate at 35 psid. However, operability of the containment isolation valves at containment design pressure of 62 psig could not be verified. The licensee has promised to supply additional information on static and dynamic operability envelope of the containment isolation valves in the subsequent few days. NMP Unit 1 purge and vent valves can be throttled and can be used to regulate the vent flowrate and downstream pressure. This feature assures vent operation to match closely the containment pressure control requirements and downstream pressure limits if SGTS vent pathway is used.

As stated earlier, the procedures are not flowcharted and do not have the stepwise details which would minimize operator errors in executing the emergency venting procedures. For this reason, the licensee is presently developing a new emergency venting procedures Section 4.1 which will address but not be limited to all significant risk contributing severe accident scenarios for which torus venting will save the containment, and assure that the fission products are scrubbed in the suppression pool prior to venting. In this way the offsite exposures could be restricted to noble gases only and timing of venting could be flexible to assure

that the evacuation in the plume exposure pathway has been completed, and meteorological conditions are favorable to minimize the health effects due to offsite releases. A hard 24-inch vent pipe, which vents directly to the plant 100 meter stack, is already operational. Therefore, no significant plant modifications are anticipated at NMP Unit 1.

The new procedures are prescriptive in nature and include predecisions for venting and will have all the necessary details which do not require the operations management staff to verbally specify how venting will be conducted. In the new arrangement, the EOPs will specify when to vent and will lay out the objectives of venting. The Section 4.0 will refer the operator to the new proposed Section 4.1 which will have all the details of stepwise actions including details of jumpering procedures. The licensee is contemplating plant modifications which will eliminate the need for jumpering by providing signal bypass capability in the control room. The procedures will be modified to reflect these changes. The new procedures described above are in draft stage. They have not been approved or implemented by the licensee.

Risk Assessment Studies and Sequences for Venting

A level 1 PRA for NMP-1 showed that initiating events contributing to core damage were dominated by transients (80%). The loss of offsite power contributed 11% to the core damage state. Based on the results of the PRA, the licensee has identified the loss of feedwater accompanied by failure to scram as the dominant accident sequence which has a scenario frequency of 3.2×10^{-4} per reactor year.

During our site visit, the licensee simulated the dominant scenario on the NMP-1 simulator and, using its venting procedures, showed how it can take advantage of the favorable plant design features discussed above to successfully recover from the transient. The containment protection was demonstrated by performing simulated emergency venting procedures via the 24-inch hard pipe vent path to the plant stack. In this way the licensee demonstrated successful recovery for a risk dominant sequence using the simulated EOPs, including venting via the 24-inch torus vent line.

Training for Emergency Venting

All of the licensed operators are trained in the normal venting procedures. Emergency venting instructions will be given to the operators by senior operators. The instructions will give the operators specific identificaion of venting pathway, throttle flowrates, and downstream pressures to be controlled.

Human Factors Considerations

- From interviews with the licensee it was determined that:

  1. The current EOPs in place are written from revision 4AC of the BWROG EPGs.

  2. The current containment venting EOP is written as general guidance. The licensee believed that it could take credit for operator knowledge and experience and therefore did not prepare detailed instruction for venting containment in its upgraded EOPs. However, during operator requalification training, operators appeared confused when using the general level of guidance contained in the procedure. The licensee is presently in the process of revising the EOPs. The planned revision will be more detailed than the current procedure. The revision is anticipated to be completed before the plant restarts in April 1988. The licensee provided the staff with copies of a draft of the revised EOP during the interview. A human factors review of the draft revision was not performed.

- From the control room/plant walkdown:

  1. A limited walkdown of the EOP and related procedures in the control room (the plant was in an outage and the control room was not readily accessible to the staff) identified that

operators could be expected to have difficulty using the current containment venting EOP concurrently with other required procedures because of the limited desk-top space available in the control room. This constraint was acknowledged by the licensee.

2. The walkdown also identified nomenclature inconsistencies between the EOP and the control room instrumentation (e.g., the operator is required by the EOP to determine if drywell temperature is below 212°F. The control room instrumentation is graduated such that the operator must estimate 212°F). The licensee acknowledged this finding and further indicated that in the current EOP there were other nomenclature inconsistencies with control room instrumentation. The licensee indicated that the revised EOP will address these instrument inconsistencies.

° From the desk top review of the EOP and associated procedures:

1. A limited desk top review of the licensee's plant-specific writer's guide for preparing EOPs, submitted as part of the licensee's Procedures Generation Package (PGP), indicated that the licensee had committed to preparing EOPs that were to be "consistent with the knowledge and capabilities of the least experienced intended user."

Based on the above observations, we conclude that, from the human factors considerations, the containment venting instructions contained in the EOP and associated operating procedures currently implemented by NMP-1 are not capable of effectively supporting operators in the mitigation of risk-dominant severe accident conditions which require venting the containment. This conclusion is further supported by the licensee's acknowledgement that the current instruction for venting does

not contain adequate detail for inexperienced operators to effectively use the instruction without receiving close supervision and supplementary direction from more experienced operators. In addition, in the current EOP and implementing procedure for containment venting (N1-OP-9, Section G.X), clear instruction is not provided to the operator for which vent path should be used under various plant conditions.

Therefore, it is possible that operators, especially those less experienced and under the stress of an emergency, might select the vent path most familiar to them (i.e., the path that would be used to vent under normal operating conditions). If the normal vent path was chosen to vent containment under emergency conditions, the potential exists that ductwork and filters which comprise part of the vent path for the SGTS would fail and that the reactor and turbine buildings could be exposed to excessive levels of radioactivity.

<u>Walkdown of Venting Systems and Equipment Called Out in Emergency Venting Procedures</u>

The staff walked down the NMP Unit 1 purge and vent pathways and observed the following.

1. The purge and vent piping is 24" diameter hard piped from drywell and torus to a common 24" pipe exhausting into a 100 meter plant stack. This pathway can bypass the SGTS.

2. The SGTS filters might blow out at pressure differences greater than 0.5 psid. If filter train pathway is used for high pressure venting, then the steam and/or fission product could be released to the reactor building.

3. The large purge/vent containment isolation valves are fitted with handwheels and are easily accessible for local manual operation. The valves are shielded from potential high radiation areas by concrete floors and walls (shielding adequacy is not known).

2.3 Susquehanna Units 1 and 2

The plant consists of twin units of GE BWR/4 with Mark II containment. Each unit has a nominal rated power of 1100 MWe. The plant's Emergency Core Cooling System consists of 2 loops of Core Spray System, one loop of High Pressure Coolant Injection System, Automatic Depressurization System of 6 relief valves, and 2 loops of Low Pressure Coolant Injection System. Other auxiliary systems include 2 loops of residual heat removal system and a Reactor Core Isolation Cooling System. The plant's Mark II containment consists of a drywell and a suppression pool connected via downcomers. Vacuum breakers are provided in the interconnections between drywell, suppression pool and reactor building.

Emergency Venting Procedures

The licensee has implemented the guidance contained in EPG Revision 3. The procedures have been written to literally follow the guidance which states that the licensee should provide for containment venting at design pressure and via the existing vent paths. The licensee has indicated that its existing vent path is a 2-inch line with 1-inch valve orifice designed to bypass the main 18-inch purge valves in the torus purge system. The reason for not using the 18-inch purge line is that it runs into a low pressure circular duct and passes through SGTS, which is not designed to accommodate pressure greater than 10 psig. The licensee stated that by adopting the small bypass venting line it has followed the guidance literally but has not met the intent of venting at design pressure (since the 2-inch bypass vent line is totally inadequate even for the minimum required rates of steam flow associated with dissipation of decay heat following reactor shutdown).

The current EOP for venting states that the operators must initiate venting procedures if the containment pressure exceeds 53 psig. The venting should be performed via the suppression pool unless the pool water level is above 38 feet. The alternate vent path is via the drywell.

The venting must be terminated if the pressure in the suppression pool or the drywell falls below 45 psig. The EOPs then direct the operator to normal operating procedure ON-134-001 which provides a detailed and stepwise guidance on venting procedures, using OP-173-001 Section 3.4 for drywell venting, and Section 3.5 for suppression pool venting. Figure 1 shows the Susquehanna containment. The drywell venting is conducted via 24-inch valve HV-15713 and 2-inch bypass valve HV-15711, keeping the second 24-inch isolation valve HV-15714 closed. The vent path then proceeds through sheet metal ducting and SGTS filter trains as shown in Figure 2. For suppression pool venting the operators will open 18-inch containment isolation valve HV-15703 and 2-inch bypass line valve HV-15705, keeping HV-15704 closed. The vent path beyond the 2-inch bypass line is via sheet metal 18-inch duct which joins the duct from the drywell purge line and proceeds via the SGTS. The ultimate release point of the vent is the top of the reactor building. There is no tall stack at Susquehanna for elevated releases of gaseous effluents.

As stated earlier the licensee is not satisfied with the emergency venting procedures, but has adopted them merely to comply with the NRC approved EPG Revision 3. These procedures have been in place since middle of 1985. The licensee stated that it did not have time to develop other venting designs which, in its opinion, would be very complex and operator action intensive. The licensee has, however, developed other venting concepts which would involve plant modifications consisting of 18-inch hard pipe (bypassing sheet metal ducts and SGTS), having a rupture disk downstream of a new 18-inch remote DC operated valve which can be opened and closed from a remote location as required. No EOPs have been drafted for larger vent paths at this time.

Risk Assessment Studies and Venting Sequences

The licensee is a participant in the Industry Degraded Core Rulemaking (IDCOR) group demonstration program for Individual Plant Examination (IPE) methodology validation for BWR 4/Mark II plant. Its risk

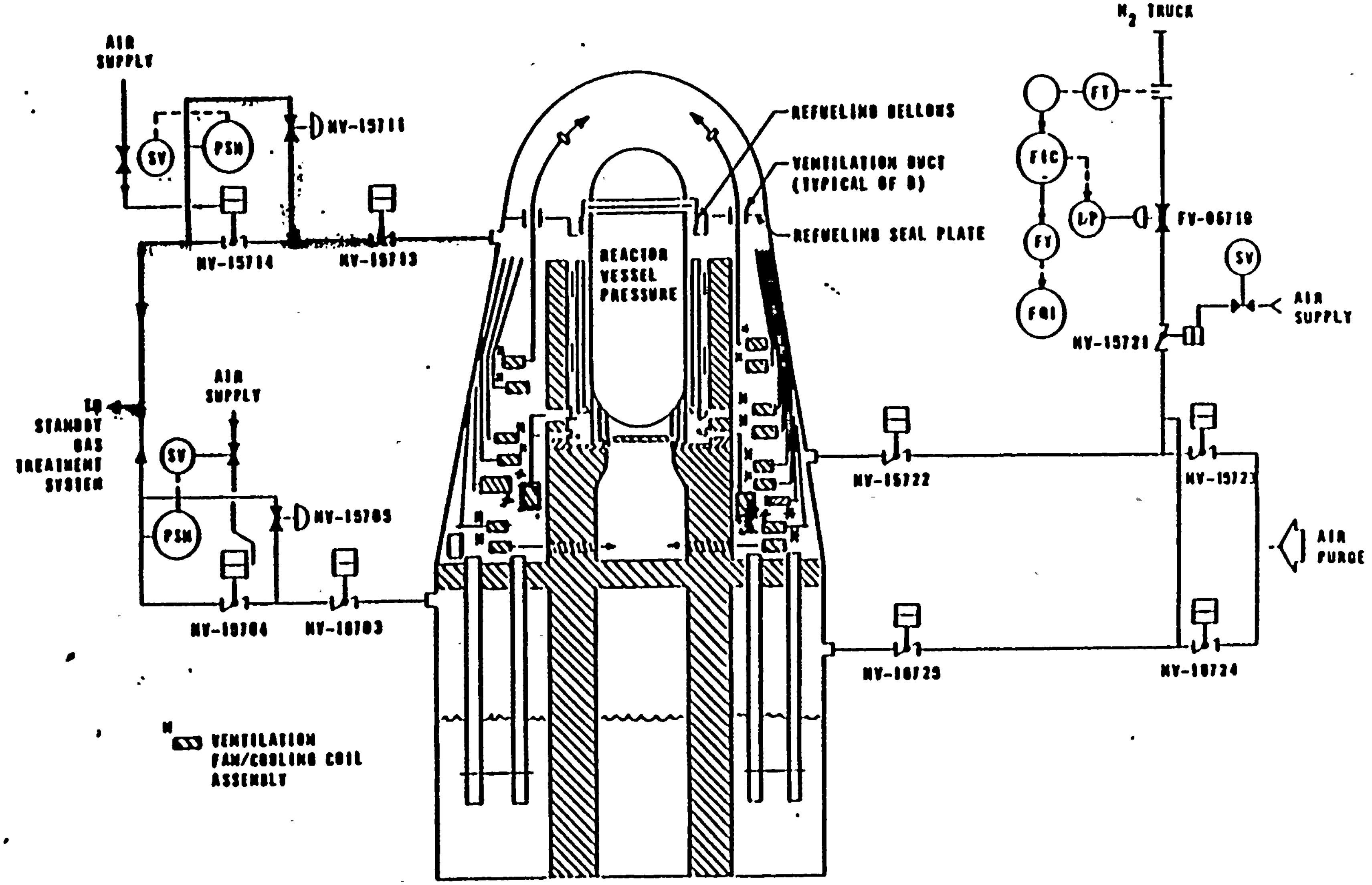
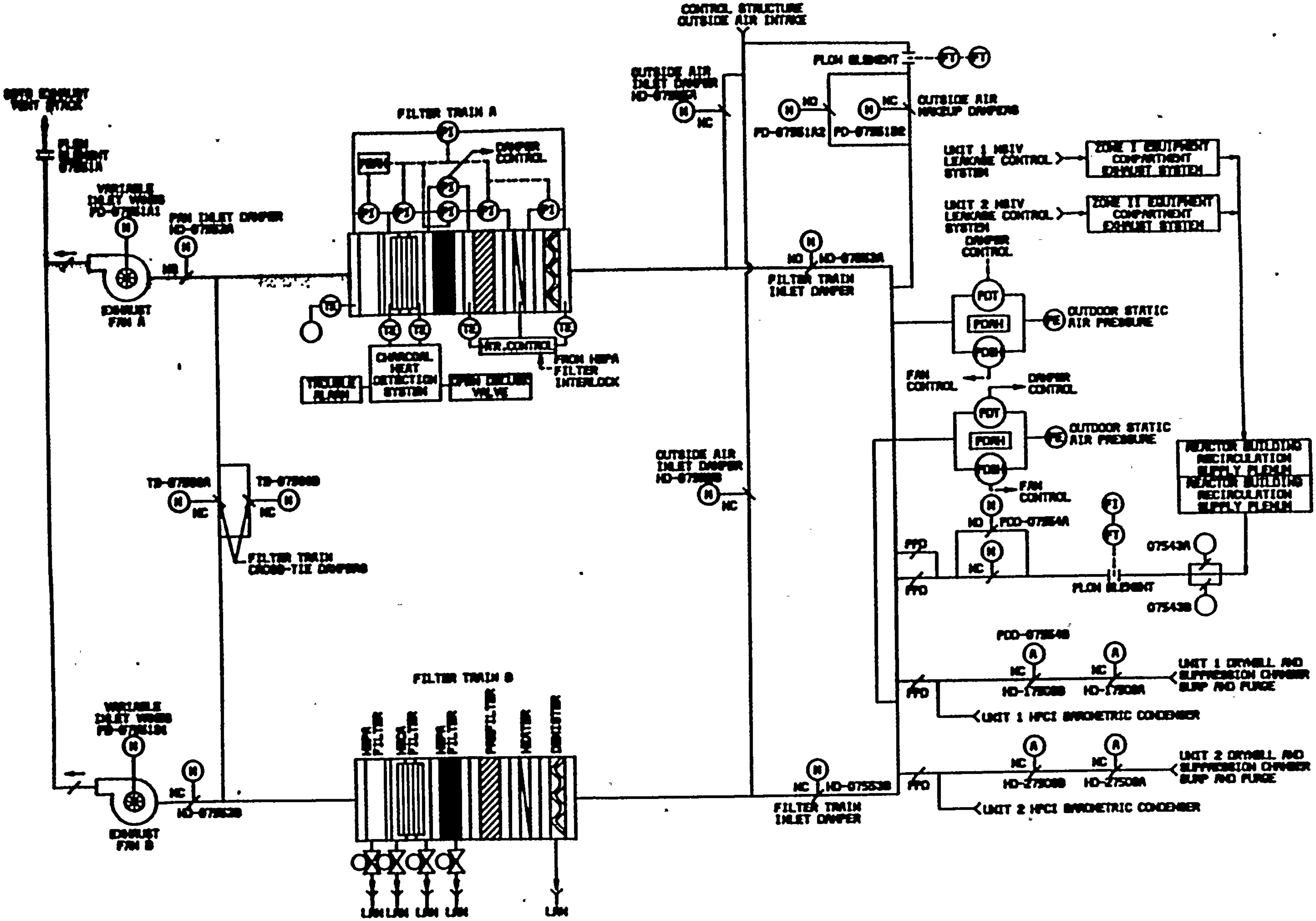


FIGURE 1

SIMPLIFIED DIAGRAM
CONTAINMENT PURGE, COOLING, AND VENTILATION

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2

Attachment 4
pg 1 of 2



NOTE: PIPING AND INSTRUMENTATION CONNECTIONS
ARE IDENTICAL ON BOTH TRAINS

FIGURE 2
STANDBY GAS TREATMENT SYSTEM
LOCA INITIATED —

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2

A 400 SHT. 336 REV. 3 DATE 10/9/85

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assessment studies performed for the SSES show station blackout sequences dominate the core melt risk spectrum. Therefore, for venting to be effective under severe accident conditions, manual operation (via local air connections of the containment isolation valves) will be necessary. This can be achieved by relatively minor modifications to provide protection against severe radiation environments expected in the vicinity of these valves during severe accidents involving core damage.

Based on its IPE analyses, the licensee has identified the following five sequences for its venting studies.

1. Loss of main condenser, suppression pool cooling, and RWCU Blowdown.

2. LOCA with loss of suppression pool cooling

3. Station blackout and no ac recovery for longer than 24 hours

4. Station blackout with failure of HPCI and RCIC start.

5. ATWS with loss of bypass and failure of SLCS.

Based on its venting study, the licensee's staff has concluded the following:

1. Provision of (hard pipe) vent capability in combination with back up generators will give indefinite Station Blackout coping capability

2. Wetwell venting is probably required to meet the licensee's fundamental policy of providing defense-in-depth using all available hardware.

3. Existing equipment with some modification can meet most requirements and concerns but may require testing of vent path integrity.

4. The current licensee evaluations are directed to provide sufficient information for the licensee management to make a decision on a venting approach and justification for its adequacy.

Venting Consequences

The licensee has evaluated the consequences of venting with the existing equipment. The licensee concludes that high pressure venting (greater than 15 psig which could result in soft ducting pressure to exceed 10 psig) will fail the existing ductwork in the reactor building. For core damage sequences the radiation levels will be high and will prevent operator entry into the reactor building to take any remedial actions. The control room ventilation system will have to be placed in recirculation mode. Some airborne radiation may leak into the control room.

The licensee studies for future concepts show that addition of a hard pipe vent system will assure low radiation levels in the reactor building. The control room ventilation system will need to be placed in recirculation mode of operation to assure that the vented fission products do not contaminate the control room atmosphere. Venting strategy will have to assure that evacuation from the plume exposure pathway has been completed and meteorological conditions are favorable for venting. The licensee will perform an integrated risk reduction study to evaluate the feasibility of future venting concepts.

Human Factors Considerations

From the desk-top review and walkdown the staff has determined the following:

1. A limited review of the EOP and the associated documentation for Primary Containment Control and the station procedures for containment venting, indicated that they generally incorporated accepted human factors practices for preparing procedures. The licensee's EOPs are in a large-scale flowchart format, with the procedures comprising 11 laminated boards. The EOPs appeared to be

easily identifiable, and conveniently located in the control room. Ample space was available for operators to effectively use them in the control room. The licensee has revised the EOPs using a low gloss laminate to eliminate the glare produced by previous versions of the EOPs. Though the EOPs appear to incorporate accepted human factors principles and enhancements (e.g., place keeping aids; some color coding), we are concerned that operators might have some difficulty in reading the procedural steps especially under low level lighting conditions, because of the small type size and overall small size of the flowchart symbols.

For example, though not directly related to the specific step in the EOP for venting containment, there are decision statements in the primary containment control EOP that have the "yes/no" logic paths reversed, i.e., some statements require a "yes" decision to follow a "right-hand" flow path in the EOP; others require the "yes" decision to follow a "left-hand" flow path. The combination of this type of inconsistency with the small type face and symbol size used in the flowcharts may cause operators to make potentially safety-significant errors using the EOP in emergency conditions. In addition to the flowchart EOPs, the licensee has, for each EOP step, a basis document. The basis document contains the EOP step, in conventional narrative format, a reference for each step to the plant-specific technical guideline and the associated EPG step and an explanation of the purpose for performing the step. The basis documents are located in the control room, available to the operators and are also used during training. The licensee uses a "reader-doer" concept for implementing the EOPs, with an SRO using the flowcharts to direct the actions of ROs at the control boards.

2. The staff was unable to exercise the EOP and related venting procedures in the simulator because an operating crew was not available. Without exercising the EOPs and associated procedures, it is difficult to conclude that the operators would be able to effectively perform their required actions under stressful conditions.

3. During the plant walkdown, the staff observed the location of several components that would be activated during containment venting. When asked if an air-operated valve (HV-15703) in the SGTS could be operated, if required under accident conditions, the licensee indicated that there is a possibility that this particular valve might become inaccessible to operators because of the potential for high levels of radiation existing in the vicinity of the valve (it is near the drywell) during some emergency conditions.

4. The licensee indicated that it has a human factors professional on the staff who is involved in the review of the EOP covering containment venting and in procedures development and revision efforts.

Based on the above observations, we conclude that the containment venting instructions contained in the EOP and associated operating procedures currently implemented by Susquehanna do not technically support venting the containment under emergency conditions. This conclusion is acknowledged by the licensee. The current EOP instruction and associated procedures generally conform to accepted human factors principles. However, some reservation exists whether or not they can be effectively and reliably implemented under emergency conditions because of the poor legibility of the EOP and because of the possible inability of operators to perform manual control manipulations, in the plant, under certain emergency conditions.

Walkdown of Venting Systems and Equipment Called Out in Emergency Venting Procedures

Unlike NMP-1 the SSES at present does not have much of the equipment needed for effective use of venting to mitigate over-pressure and hydrogen burn challenges to the containment for those accident sequences when the containment pressure is likely to be high (greater than 20 psig). Although the plant has containment isolation valves (in the 24 inch drywell vent line and 18 inch torus vent line), which are qualified for design basis LOCA containment pressure and environment, the plumbing between these valves and the external vent release point is via the SGTS and consists of duct work which is unlikely to withstand pressure above 10 psig. Opening these valves during severe accidents, when the containment may reach design pressure (53 psig), will certainly fail the duct work and release steam, hydrogen and noble gases from the primary containment to the reactor building (secondary containment). The releases in the secondary containment may preclude availability of some unfailed safety equipment and complicate post-accident recovery efforts involving operator entry to use that equipment. Moreover, the vent release to the atmosphere is located on the roof of the reactor building and any releases of noble gases via this vent path would behave like ground level releases outside the reactor building, if the duct work survives the venting pressures. SSES purge and vent containment isolation valves' handwheels have been removed to prevent inadvertent manual operation. However, these air operated valves can be operated via manual local air connections. The venting study indicates that Station Blackout (SBO) sequences dominate the core melt frequencies. Therefore, for venting to be effective under risk-dominant accidents, manual operation via local air connections of the containment isolation valves will be necessary. This can be achieved by relatively minor modifications to provide protection against severe radiation environments expected in the vicinity of these valves during severe accidents involving core damage (SSES valves are also separated from the suppression pool by a heavy concrete wall).

3.0 CONCLUSIONS

The staff's inspection confirmed that there is a wide diversity of plant-specific venting EOPs.

There are significant variations in the designs of the containments and the safety systems. At some plants the venting can be implemented with the current hardware. At other plants substantial modifications will be needed to achieve the objectives of venting in a safe manner.

For those plants where SBO sequences are dominant and where the vent paths are routed via soft piping, hard pipe modifications would be needed for deriving maximum benefit of emergency venting.

For plants which do not have tall (100 meters) stacks, release of fission products via the vent path may require modifications to prevent fission products infiltration into the control room.

At NMP-1, the venting can safely mitigate the consequences of the dominant accident sequences. The present containment venting and associated support procedures at NMP-1 do not provide the necessary details to prevent operator errors. The revision under preparation will contain greater instructional detail.

At SSES, SBO sequences dominate the risk and venting is routed via soft pipe paths. The licensee has therefore adopted venting via 2-inch line with 1-inch valve orifice to assure low downstream pressure. While this arrangement may prevent failure of soft pipes downstream of the 1-inch orifice, it also prevents adequate vent flowrate to deal with expected severe accident challenges of containment over-pressurization. Though the licensee's procedures appeared to incorporate accepted human factors practices, the overall small size of the EOP text and symbols may detract from the effectiveness of these procedures under emergency conditions.