Task 5. Selection of Containment Response Analysis Code

Hydrogen releases of the magnitude considered by this program have not previously been identified as a design basis for nuclear power plants. A familiar and extensive library of verified analytical codes for analysis of the containment response to such an event is therefore not available. Codes which could be used must be identified, developed, and/or adapted to perform the analysis of hydrogen burns for Mark III containments. They must in addition be verified as accurately predicting containment response consistent with the limitations inherent in the model assumptions and input data. Complete documentation of the code and verification procedure will be provided for regulatory review. Figure 4-6 illustrates Task 5.

Subtask 5.1. Survey available codes

Available codes in the nuclear power industry were surveyed to determine the most efficient choice for analysis of the postulated hydrogen burn. It was found that no presently available code adequately modeled the hydrogen burn phenomena in a compartmentalized pressure suppression Mark III containment.

Decision Point 5.2. Select code

This decision required selection of a code to analyze the postulated hydrogen burn in the Mark III containment. Selecting an existing code without modification was not a viable option, as determined in Subtask [illegible] During the survey conducted at [illegible] the HCOG found that Offshore Power Systems (OPS) has used a code titled CLASIX for performing analysis of hydrogen combustion in the Sequoyah and McGuire containments. The code included many elements common to the Mark III containment and OPS had prepared a plan for verifying this code. Based on these facts, the HCOG determined that it would be more cost effective if the CLASIX code were modified rather than a new code developed.

Subtask 5.3. Modify CLASIX to include Mark III features

The CLASIX code was developed to model hydrogen burn transients in an ice condenser containment. Modifications were required to analyze a horizontal vent pressure suppression Mark III containment. These modifications included the addition of suppression pool dynamics, upper containment pool interaction, and spray carry over from the containment to the wetwell. Concurrent with these changes, the program was generalized to allow flow between any two compartments and the number of volumes, flow paths, walls, etc., were increased. The modified code was renamed CLASIX-3.

Subtask 5.4. Preliminary verification of CLASIX

CLASIX and CLASIX-3 both analyze the pressure and temperature response of the containment during a hydrogen combustion transient. Other containment pressure and temperature transients, such as a pipe break, can also be modeled in CLASIX. The results from modeling these transients in CLASIX can be compared with analytical results from other verified and accepted containment response codes. A small pipe break in the containment was modeled and analyzed with CLASIX. The same accident was modeled in the multi-compartmented code TMD and in the single compartment code COCO. The analytical results from TMD and COCO indicated that CLASIX provides reasonable containment temperature and pressure responses. In addition, some of the unique portions of CLASIX-3 were verified with hand calculations. Portions of the program verified by hand included suppression pool dynamics and mass energy relationships.

Subtask 5.5. Develop representative Mark III model for CLASIX-3

A specific model of the Mark III containment must be developed before any actual verification of the CLASIX-3 program can be accomplished. Mississippi Power & Light Company's Grand Gulf Nuclear Station (GGNS) was chosen as being representative of the Mark III type of containment. Specific values for containment volume, suppression pool volume, hydrogen evolution, etc., from GGNS were used in the initial verification and sensitivity studies.

Plant specific features such as structural heat sinks were included as well as containment spray and the design interactions between compartments, (i.e., drywell purge and vacuum breakers, spray carry over estimates, etc.).

Subtask 5.6. Perform verification and sensitivity studies

Several transients were selected and run with CLASIX-3 to identify potentially anomolous results. These transients provided variation in hydrogen burn parameters, hydrogen release conditions, and concentrations, and conditions for various compartment atmospheres.

Varying the parameters in this fashion assures that the CLASIX-3 model is not unduly sensitive to changes in particular input parameters. This sensitivity analysis is part of the process of verifying CLASIX-3.

Subtask 5.7. Submit topical report verifying CLASIX to NRC

The CLASIX-3 code is an adaptation of the ice condenser containment code, CLASIX. The CLASIX code was used in the containment response analysis of both the Sequoyah and McGuire plants. Formal verification of the base code is completed. This verification has been submitted to the NRC in a topical report. Verification of the CLASIX code, and thus the basic hydrogen burn model, is an essential element in the verification of the CLASIX-3 code.

Decision Point 5.8. Determine if additional verification is required

The HCOG will review the verification work completed to date and determine if further work is required. The verification work must provide assurance that the CLASIX-3 results are conservative regarding actual phenomena and that the results are consistent with minor variations in the input parameters.

Subtask 5.9. Complete additional verification

If the HCOG determines that additional verification is required, then they will specify the scope of this effort. A number of possibilities exist for additional verification including further hand calculations, and more sensitivity runs.

Subtask 5.10. CLASIX-3 description of verification report

A report will be generated detailing the steps taken to verify CLASIX-3. This report will reference and summarize the verification performed on CLASIX and will document additional verification performed on the modifications which produced CLASIX-3. Included will be results of hand calculations used to verify the suppression pool dynamics, and appropriate sensitivity runs plus additional verification work as applicable to the final verification program.

Subtask 5.11. Submit CLASIX-3 report to NRC

OPS will submit a separate report verifying the CLASIX-3 version of CLASIX to the NRC. This report, generated at Subtask 5.10, will provide appropriate references to the CLASIX code topical report submitted at Subtask 5.7.

Task 6. Containment Response Analysis

Postulated hydrogen burns in the Mark III containments produce significant pressure, temperature, and gas concentration transients. These transients potentially exceed the design parameters of the containment structures and of the safety related equipment inside the containments. Extensive analyses of the containment response to the postulated hydrogen burn event is therefore required in order to quantify the potential transients. These analyses will form the basis for verifying the individual containment integrity for postulated hydrogen burn events, for proceeding with equipment survivability analyses, and for assuring the adequacy of the HIS.

Potential variations in burn parameters, systems availability, and initial conditions will be bracketed by performing various sensitivity studies on the containment response. The analysis will be conducted initially on a generic basis. Sensitivity studies which bound the potential variations between plants in major parameters will be conducted. This generic work will be refined with individual plant specific analysis and possibly plant specific sensitivity studies. Task 6 is illustrated in Figure 4.7.

Subtask 6.1. Establish preliminary burn parameters

Preliminary burn parameters for the generic analyses were established based on the work performed for the Sequoyah and McGuire and based on the results of phenomena testing conducted by Fenwal and Singleton Laboratories. These preliminary burn parameters included values for hydrogen concentration necessary for combustion, fraction of hydrogen consumed, oxygen concentrations required to support combustion and flame velocity.

Subtask 6.2. Review generation rates from MARCH

Hydrogen generation rates have been calculated by Battelle Columbus using the MARCH code which predicts hydrogen release rates. These calculations assume a loss of coolant equivalent to one SORV and the complete failure of all emergency cooling systems. The hydrogen generation rates were utilized as input to the CLASIX-3 analysis.

The hydrogen generation rates which were used in the CLASIX-3 analysis will be reviewed to assure that the release rates are consistent with the calculated release rates from Subtask 1.5 or that the MARCH release rates do not decrease the conservatism of the calculations.

Subtask 6.3. Establish generic Mark III base case

The generic Mark III base cases which are being used for the primary sensitivity studies have used input parameters from MP&L's GGNS. The first base case run assumed that the evolved hydrogen was released into the suppression pool. The second base case run assumed that the evolved hydrogen was released into the drywell. Results from these base cases will be in the final individual containment response reports as appropriate.

Subtask 6.4. Perform generic Mark III base case analyses

The two base cases identified in Subtask 6.3 have been analyzed with CLASIX-3. The resulting generic transient responses will be considered as reference pressure and temperature responses for containment capability analyses.

Subtask 6.5. Specify generic Mark III sensitivity runs

Using the base case analyses generated in Subtask 6.4, parameter variations for sensitivity runs were selected. These selections were made in order to compensate for uncertainties in the accident scenario, system availability, input parameters, and the code model. They were also be selected to provide a high degree of confidence in the containment capacity.

Subtask 6.6. Complete generic sensitivity analysis

The sensitivity runs specified in Subtask 6.5 will be completed with CLASIX-3. The results of these runs will be closely reviewed to assess which parameters create significant changes in the analytical results. The output from these sensitivity runs will be included in the generic Mark III containment response report prepared at Subtask 6.7.

Subtask 6.7. Submit generic Mark III report to NRC

The HCOG will submit the results obtained in Subtasks 6.4 and 6.6 to the NRC. This submittal will include a description of the input parameters and assumptions used in the generic analysis. Individual utilities will reference the generic report in their separate containment response reports.

Subtask 6.8. Assure generic runs bound individual plants

Each utility is responsible for assuring that the generic owners group analysis bounds the specific plant designs. The utilities must assure that sensitivity studies encompass variations between the generic Mark III design and individual plants.

Subtask 6.9. Prepare containment response report

Appropriate analytical work performed in Subtasks 6.7 will be summarized in report form. The plant specific base cases and additional analyses will be included along with key assumptions and input parameters for each. Pressure, temperature, and gas concentration results for each case will be documented as well as tables summarizing the key results (i.e., maximum pressure, temperature, etc.) from the analyses. Each utility may reference portions of the generic Mark III analysis and generic sensitivity runs submitted at Subtask 6.7 as appropriate.

Subtask 6.10. Submit containment response report to NRC

Each utility will separately submit its own containment response report. The individual utilities will select the format for these reports and establish schedules consistent with their own particular licensing requirements.

Task 7. Hydrogen Combustion Testing and Analysis

Publication of the NRC's interim rule initiated a broad spectrum of activity related to hydrogen combustion, behavior of hydrogen, and hydrogen control system design. These activities include fundamental research, applied research, analytical modeling, scale testing and full scale testing. These activities have been sponsored and executed by both private companies and government agencies.

The HCOG has been monitoring research and analysis regarding hydrogen since the group's inception. The HCOG is considering participation in continuing research projects which will provide additional knowledge about the behavior of hydrogen and hydrogen combustion. The HCOG is also considering sponsoring its own testing program to verify expectations regarding behavior of hydrogen and hydrogen combustion in the Mark III type containment.

This task also incorporates certain analysis which is being provided to support member utility licensing efforts. This analysis provides the basis for a variety of assumptions concerning the behavior of hydrogen in a BWR/6, Mark III containment. Task 7 is illustrated in Figure 4-8.

Subtask 7.1. Evaluate Fenwal Test results

Fenwal Incorporated, a private testing laboratory, conducted a series of tests which demonstrated glow plug performance in late 1980. The tests were conducted at Fenwal by Westinghouse for TVA, Duke Power and American Electric Power (AEP). Fenwal conducted the tests on the GMAC model 7G igniter using varying concentrations of hydrogen and steam and varying mixing rates using water sprays.

The tests demonstrated that igniters will initiate combustion with hydrogen concentrations between six and twelve percent by volume. Total combustion of the hydrogen does not occur below approximately 8.5 percent concentration. At higher hydrogen concentrations, above approximately 8.5 or 9 volume percent, complete hydrogen combustion occurs.

The use of water sprays had no effect on the ability of the glow plugs to initiate combustion. The sprays promoted more complete combustion of hydrogen at lower volume concentrations.

Steam concentrations up to 40 volume percent did not prevent the glow plugs from initiating combustion. The presence of steam tended to reduce the peak pressure created by the combustion of hydrogen.

Subtask 7.2. Evaluate Lawrence Livermore test results

The NRC sponsored a series of tests at Lawrence Livermore National Labs to support the staff's review of Sequoyah Nuclear Power Plant's hydrogen ignition system. These tests were essentially repetitions of the Fenwal tests, and the results were substantially in agreement with the Fenwal test results.

The tests again showed hydrogen ignition at concentrations between six and ten volume percent. Complete combustion again occurred at higher concentrations and mixing, such as that induced by water sprays, promoted more complete combustion at lower hydrogen concentrations.

Subtask 7.3. Evaluate Singleton test results

TVA conducted a series of tests on commercially available igniters at their Singleton Laboratories. These tests demonstrated that the glow plugs were capable of maintaining temperatures around 1500°F at a variety of voltages. The tests resulted in TVA's selection of the GMAC model 7G glow plug.

Subtask 7.4. Evaluate on-going industry effort

The HCOG embarked upon a comprehensive evaluation of other research and analysis concerning hydrogen combustion in conjunction with the review of the Singleton, Fenwal and Lawrence Livermore test results. These evaluations included compilation of a list of organizations sponsoring and conducting additional research and review for applicability of all presently completed research.

This evaluation established the research efforts most applicable to the Mark III design efforts. Separate monitoring programs were established for many of these efforts.

Subtask 7.5. Monitor IDCOR activities

The NRC is planning to hold a rulemaking proceeding to establish design requirements for degraded cores including hydrogen effects. The nuclear power industry is attempting to develop a unified response to the NRC's concerns. The Industry Degraded Core Rulemaking (IDCOR) study group is developing a research program and performing analysis work in support of developing this unified position. As indicated at Decision Point 2.5, the HCOG is participating in this effort and intends to use this generic effort to document the HIS selection process.

Subtask 7.6. Monitor NRC/Sandia activities

Sandia National Labs is conducting a series of tests for the NRC regarding hydrogen behavior. Research work to date includes experiments with equipment survivability, mixing induced by turbulence, and flame velocity. The NRC is sponsoring continuing research at Sandia which is designed to support the staff's licensing review of hydrogen control systems. Much of this research will concern hydrogen ignition systems in BWR/6, Mark III containments.

Subtask 7.7. Monitor DOE research - Sandia

The Department of Energy has recently inaugurated a separate research program at Sandia National Labs. The scope and goals of this research have not been firmly established. However, the research program will deal with fundamental phenomena associated with hydrogen combustion. The HCOG will continue to follow DOE's research efforts.

Subtask 7.8. Monitor Brookhaven analysis of GGNS containment

Brookhaven National Labs has conducted an independent evaluation of the GGNS containment structure for the NRC. The analysis is intended as an independent verification of the ultimate capacity of the GGNS containment.

The HCOG will review the final results from the Brookhaven evalution when they are made available. The utilities will be notified by the HCOG if any changes are required for calculating ultimate capacity.

Subtask 7.9. Establish final burn parameters for analysis

The HCOG has utilized the expertise of Combustion and Explosives Research (COMBEX) Inc., to establish final burn parameters. The parameters which must be established include hydrogen concentration at which combustion occurs, completeness of combustion, minimum oxygen requirements, and flame velocity.

The burn parameters have been determined based on COMBEX's extensive experience with hydrogen combustion and upon a review of the preliminary results from the Electric Power Research Institute's testing program.

Subtask 7.10. Investigate Mark III unique phenomena

Several potential phenomena relate uniquely to hydrogen combustion in the Mark III type containments. As an example, hydrogen combustion in the drywell may be suppressed due to insufficient oxygen. Accumulated hydrogen may burn gradually as oxygen is reintroduced into the drywell. COMBEX investigated this issue, factors contributing to mixing, and other Mark III unique features. COMBEX reviewed these phenomena to determine if additional testing is required.

Decision Point 7.11. Participate in EPRI studies

The EPRI program consists of a series of four sets of tests; at Acurex, Canada's Whiteshell Labs, Westinghouse's Hanford Labs, and the Nevada test site. This decision relates to whether or not the HCOG intends to provide part of the financing for this program and thus share in usage of the resulting data.

The bulk of the tests will address issues which are at least partially applicable to Mark III type containments. Issues which will be studied include equipment survivability, combustibility of various concentrations of hydrogen, completeness of burning, flame velocity, glow plug survivability and a variety of other items.

Subtask 7.12. Evaluate final EPRI results

If the HCOG elects to participate in the EPRI tests they will evaluate the final results generated by the EPRI tests. The preliminary test results will be used to help establish the final burn parameters at Subtask 7.9 if they are available to the HCOG. The final results should confirm the final burn parameters and verify other assumptions.

Subtask 7.13. Recommendation on additional testing

COMBEX provided the HCOG with a recommendation concerning additional testing. The recommendations included the type of tests required and the scope of the testing.

COMBEX based their recommendations on the evaluation conducted in Subtask 7.10.

Decision Point 7.14. Additional testing required

The HCOG will make the final decision regarding the need for additional testing. This decision will be based on the COMBEX recommendation from Subtask 7.13 and regulatory requirements.

Subtask 7.15. Perform additional testing

If the HCOG elects to conduct additional testing, they will establish the scope of testing, the issues to be addressed in the tests, and the exact data which should be obtained. The HCOG will manage, direct and analyze the results from the tests.

Subtask 7.16. Submit test results to NRC

Test results will be submitted to the NRC in the form of a report when they become available. The report will include a discussion of how the test results effect the completed analysis.

Task 8. Equipment Survivability Analysis

The combustion of hydrogen in the containment by the HIS produces short duration spikes in temperature and pressure. Equipment whose function is determined to be essential during or after the hydrogen burns must be shown to remain functional. The HCOG and General Electric are developing generic lists of essential equipment which must survive these transients. These generic lists will be reviewed and revised by each utility as required to assure that all essential equipment is included.

Each piece of essential equipment will be reviewed to assure that it is capable of surviving postulated hydrogen burns. The environmental qualification documentation will be checked to determine if the essential equipment will survive peak temperature and pressure.

The HCOG will develop heat transfer models of the equipment. The models will be used to calculate the peak temperatures of the most critical components of each piece of equipment. If the calculated peak temperature still exceeds the environmental qualification temperature, then the equipment may be shielded from the containment temperature spikes, tested to verify that it can survive a hydrogen combustion event, or replaced with new equipment which will survive.

The equipment survivability analysis program will be closely monitored to assure that all phenomena have been considered. If changes occur due to new test results or revised design bases, the completed analyses will be checked to verify conservatism. Task 8 is illustrated in Figure 4.9.

Subtask 8.1. Criteria for equipment survivability

The equipment survivability program began with the selection of criteria for use in identifying equipment required to survive hydrogen combustion. Essentially two criteria were selected:

1. Systems and equipment which must function to maintain core geometry, maintain the integrity of the containment pressure boundary, or mitigate the consequences of the event.
2. Systems and equipment which would assist in monitoring the event.

Subtask 8.2. Identify essential BOP equipment

A list of equipment which must remain functional following the postulated hydrogen burns has been developed by the HCOG. This list will include components and instrumentation meeting the criteria established in Subtask 8.1. The HCOG will review the equipment on this list to identify the most critical component on each assembly. This component is defined as the component most sensitive to significant changes in temperature.

Subtask 8.3. Identify essential NSSS equipment

The HCOG requested General Electric to prepare a generic list of essential equipment for the BWR/6 NSSS. This program includes an evaluation of the importance to safety of each piece of equipment.

Subtask 8.4. Adjust lists for plant specific design

Each utility will adjust the lists prepared at Subtasks 8.2 and 8.3 so that they include all plant specific items. The utility will determine the most critical component for each piece of equipment added to the two lists. The final lists generated by each utility at this Subtask will represent all the equipment which must survive postulated hydrogen combustion.

Decision Point 8.5. Assess potential for common survivability analysis

The HCOG will determine the extent to which survivability analysis can be conducted generically. This will include a review of the specific pieces of equipment used in different plants to identify where common equipment has been used.

Depending on the extent of common equipment, and upon the nature of variations between plant unique containment responses, subsequent survivability analysis may be conducted by individual utilities and the HCOG in parallel.

Subtask 8.6. Select design basis temperature and pressure profiles

The temperature and pressure profiles which will be used for demonstrating equipment survivability will be chosen from the generic Mark III base case and sensitivity runs. The profiles selected will be those which reflect the most probable accident scenario.

Subtask 8.7. Evaluate industry survivability experience

The HCOG will review all work performed in the area of equipment survivability. This review will include work performed by TVA and Duke Power for the Sequoyah and McGuire plants respectively, the survivability testing conducted by EPRI if the HCOG participates in the EPRI program, and the survivability work completed by MP&L for GGNS.

The review will be performed with the intent of reducing needless duplication of effort by HCOG member utilities. If specific pieces of equipment have already been shown to survive postulated hydrogen combustion, this will be documented in the survivability analysis report.

Decision Point 8.8. Peak pressure exceeds equipment qualification pressure

The peak pressure in the containment established at Subtask 8.6 will be compared against the pressure that each individual piece of equipment is qualified to withstand by the environmental qualification program. If the peak pressure is less than the qualified pressure, this will be documented in the equipment survivability report. If the peak pressure exceeds the qualified pressure, the equipment will be reviewed under Subtask 8.9.

Subtask 8.9. Document equipment survival

The equipment design will be reviewed for sensitivity to pressure transients if the environmental qualification pressure is less than the peak pressure created by a hydrogen burn. The manufacturers of specific pieces of equipment will be requested to certify the capability of their equipment to withstand pressure transients if this capability cannot be readily demonstrated by inspection or analysis. The adequacy of each piece of equipment will be documented in the equipment survivability report.

Decision Point 8.10. Peak temperature exceeds equipment qualification temperature

The peak temperature in the containment established in Subtask 8.6 will be compared against the temperature that each piece of equipment is qualified to withstand by the environmental qualification program. If the environmental qualification temperature exceeds the peak containment temperature, this will be documented in the equipment survivability report. Equipment which does not pass this test will be analyzed in Subtask 8.11.

Subtask 8.11. Thermal analysis for critical components

A heat transfer model will be developed for each piece of equipment which fails the test established at Decision Point 8.10. This model will be used to calculate the maximum temperature that will occur at the critical component. Due to the short duration of hydrogen combustion induced temperature spikes, the actual peak temperature at the critical component is expected to be much lower than the peak temperature in the containment.

Decision Point 8.12. Critical component temperature exceed qualification temperature

The peak temperature at the critical component which is determined at Subtask 8.11 will be compared with the environmental qualification temperature. If the peak temperature at the critical component is the lower of the two temperatures, this will be documented in the equipment surivability report. New survivability testing, replacement of the equipment or some form of thermal shielding to protect the equipment from temperature spikes will be required if the peak critical component temperature exceeds the environmental qualification temperature.

Subtask 8.13. Submit preliminary survivability report

The HCOG will submit a preliminary survivability report which will describe components that have been reviewed in the survivability analysis. This report will contain the lists generated at Subtasks 8.2 and 8.3 along with the evaluation of industry experience performed at Subtask 8.7.

Decision Point 8.14. Method of assuring equipment survival

If critical component peak temperatures exceed the environmental qualification temperatures, each utility will have to determine the best method for assuring that the equipment remains functional. In many cases the equipment can be shielded from radiant thermal energy associated with hydrogen combustion. The utility will make a decision on the economics of shielding the equipment versus testing the equipment in a hydrogen combustion environment or replacing the equipment with new equipment designed to withstand hydrogen combustion.

Subtask 8.15. Perform survivability testing

The HCOG will arrange for and manage any testing which is conducted to demonstrate that equipment will survive hydrogen combustion. The testing parameters will be established by the HCOG based on the requirements of all member utilities. The HCOG will evaluate test results and distribute the results to member utilities. Applicable results will be included in the equipment survivability reports.

Subtask 8.16. Procure replacement equipment

Member utilities will be individually responsible for procurement of replacement equipment if this option is deemed appropriate. Design requirements which guarantee equipment survival of hydrogen combustion events will be described in the equipment survivability report.

Subtask 8.17. Provide thermal shields

Some type of shield or insulation may provide the most effective protection for some types of equipment. If shields are selected to protect equipment, the shields must be designed and installed. Adequacy of the shields to protect equipment from temperature spikes will be demonstrated in the equipment survivability report.

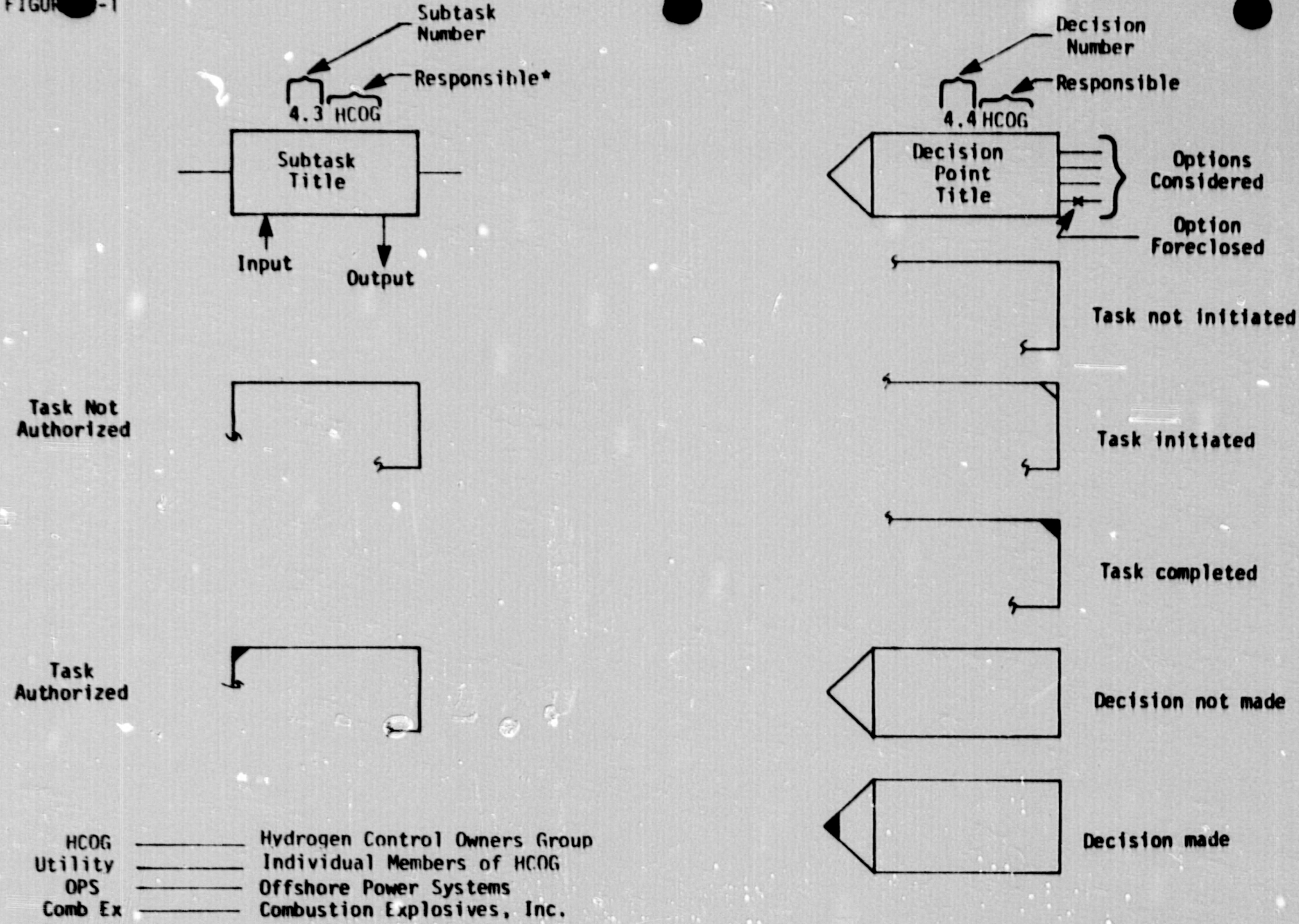
Subtask 8.18. Prepare equipment survivability report

The final equipment survivability report will demonstrate that each essential piece of equipment in the containment is capable of surviving hydrogen combustion. It will discuss how this is demonstrated by existing environmental qualification data, analysis and environmental qualification data, or some other method, such as testing or shielding.

Subtask 8.19. Submit survivability report to NRC

Each utility will be responsible for submitting to the NRC the individual equipment survivability analysis developed at Subtask 8.18. This analysis may rely upon previously completed work, new analysis, or analysis shared by the HCOG.

FIGUR -1



Subtask Number
Responsible*
4.3 HCOG
Subtask Title
Input
Output
Decision Number
Responsible
4.4 HCOG
Decision Point Title
Options Considered
Option Foreclosed
Task not initiated
Task Not Authorized
Task initiated
Task completed
Task Authorized
Decision not made
Decision made
HCOG — Hydrogen Control Owners Group
Utility — Individual Members of HCOG
OPS — Offshore Power Systems
Comb Ex — Combustion Explosives, Inc.

FIGURE 4-2

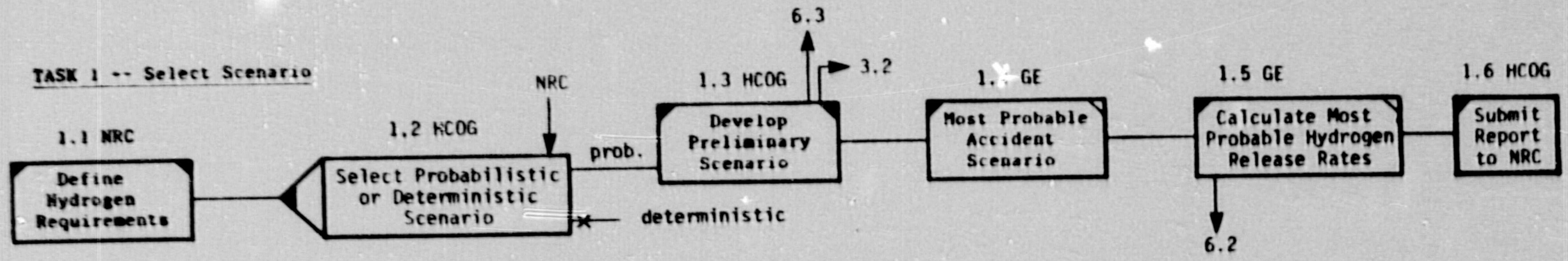

TASK 1 -- Select Scenario
1.1 NRC
Define Hydrogen Requirements
1.2 HCOG
Select Probabilistic or Deterministic Scenario
NRC
prob.
deterministic
1.3 HCOG
Develop Preliminary Scenario
6.3
3.2
1. GE
Most Probable Accident Scenario
1.5 GE
Calculate Most Probable Hydrogen Release Rates
6.2
1.6 HCOG
Submit Report to NRC

FIGURE 4-3

TASK 2 -- Select Mitigation System

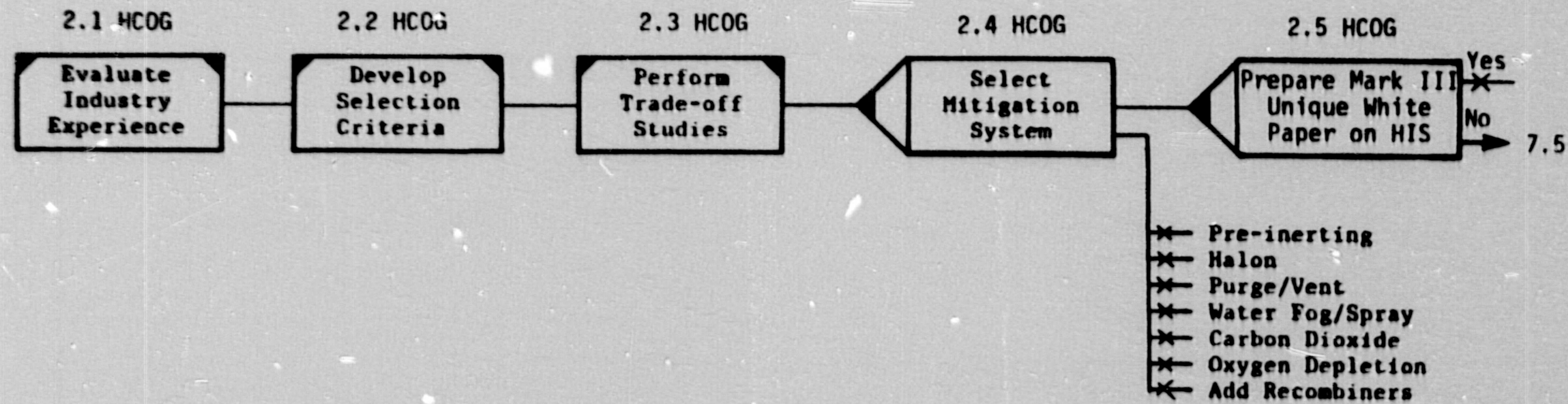


FIGURE 4-4

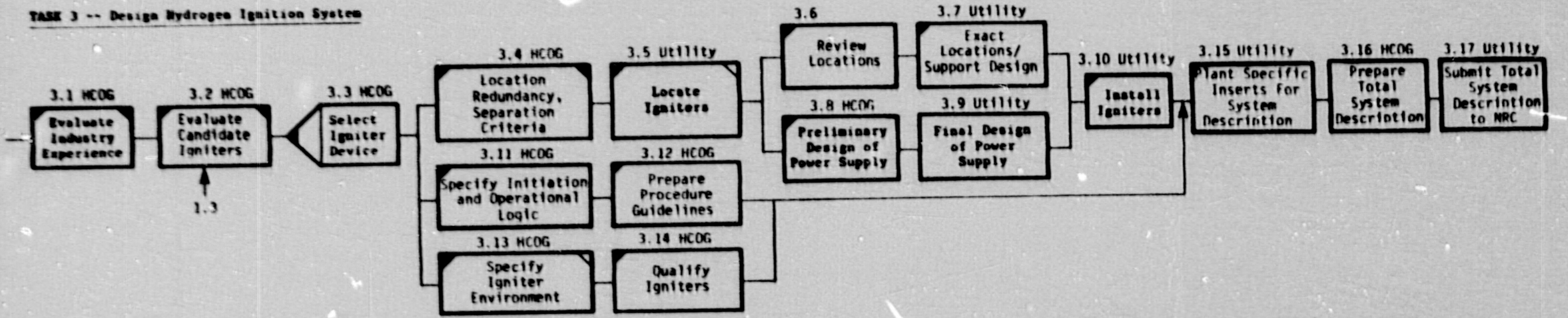
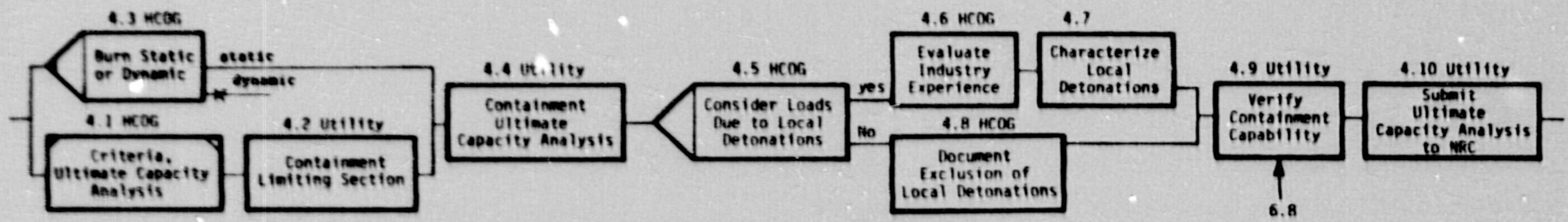
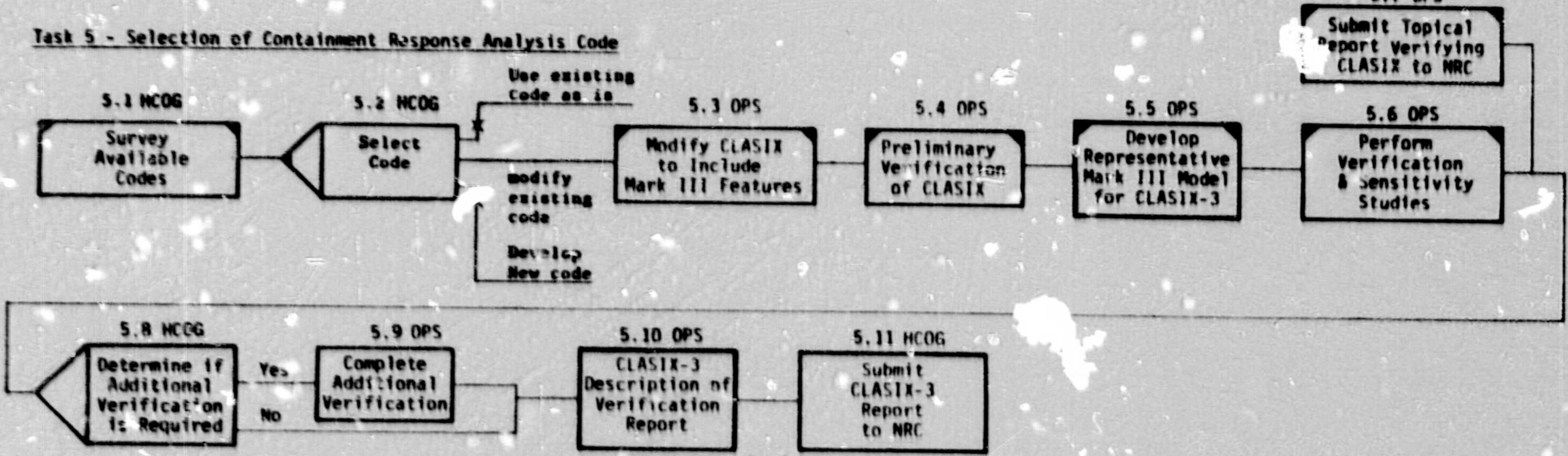

TASK 3 -- Design Hydrogen Ignition System
3.1 HCOG
Evaluate Industry Experience
3.2 HCOG
Evaluate Candidate Igniters
1.3
3.3 HCOG
Select Igniter Device
3.4 HCOG
Location Redundancy, Separation Criteria
3.5 Utility
Locate Igniters
3.6
Review Locations
3.7 Utility
Exact Locations/ Support Design
3.8 HCOG
Preliminary Design of Power Supply
3.9 Utility
Final Design of Power Supply
3.10 Utility
Install Igniters
3.11 HCOG
Specify Initiation and Operational Logic
3.12 HCOG
Prepare Procedure Guidelines
3.13 HCOG
Specify Igniter Environment
3.14 HCOG
Qualify Igniters
3.15 Utility
Plant Specific Inserts For System Description
3.16 HCOG
Prepare Total System Description
3.17 Utility
Submit Total System Description to NRC

FIGURE [illegible]-5

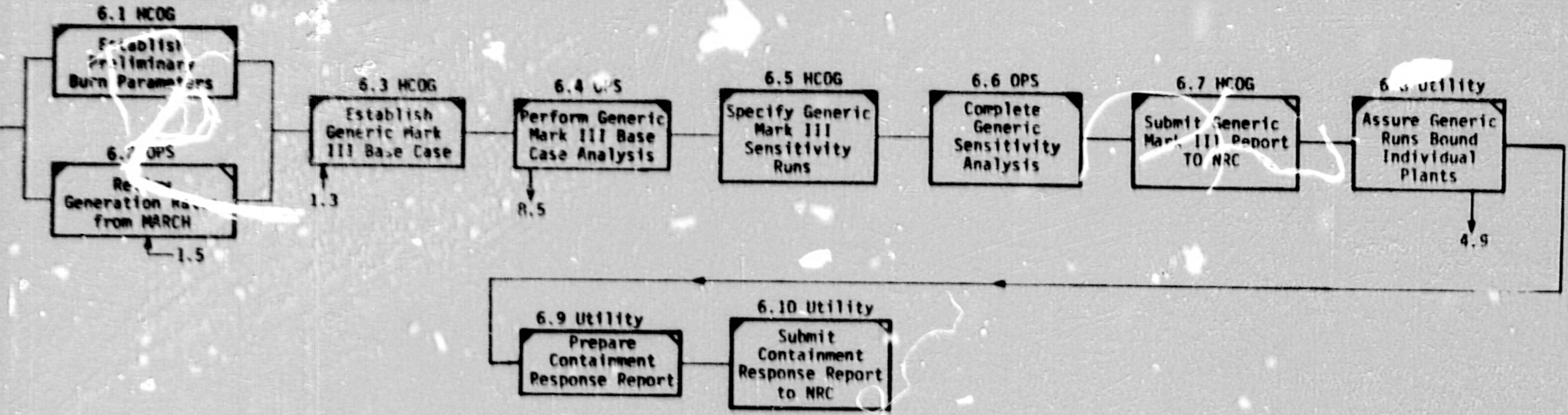
TASK 4 -- Containment Ultimate Capacity Analysis




Task 5 - Selection of Containment Response Analysis Code
5.1 HCOG
Survey Available Codes
5.2 HCOG
Select Code
Use existing code as is
modify existing code
Develop New code
5.3 OPS
Modify CLASIX to Include Mark III Features
5.4 OPS
Preliminary Verification of CLASIX
5.5 OPS
Develop Representative Mark III Model for CLASIX-3
5.6 OPS
Perform Verification & Sensitivity Studies
5.7 OPS
Submit Topical Report Verifying CLASIX to NRC
5.8 HCOG
Determine if Additional Verification is Required
Yes
No
5.9 OPS
Complete Additional Verification
5.10 OPS
CLASIX-3 Description of Verification Report
5.11 HCOG
Submit CLASIX-3 Report to NRC

FIGURE

Task 6 - Containment Response Analysis



Task 7 - Hydrogen Combustion Testing & Analysis

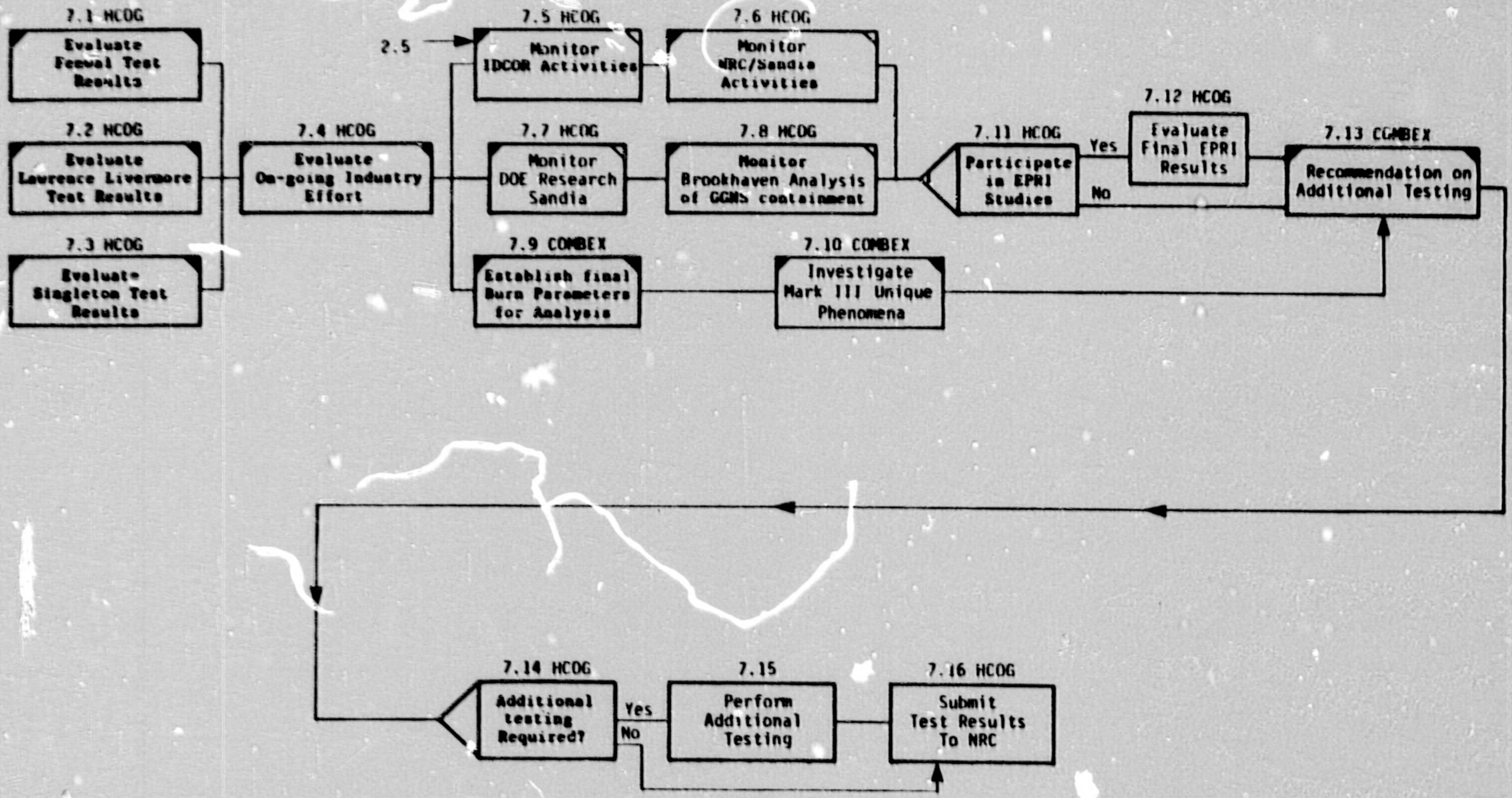
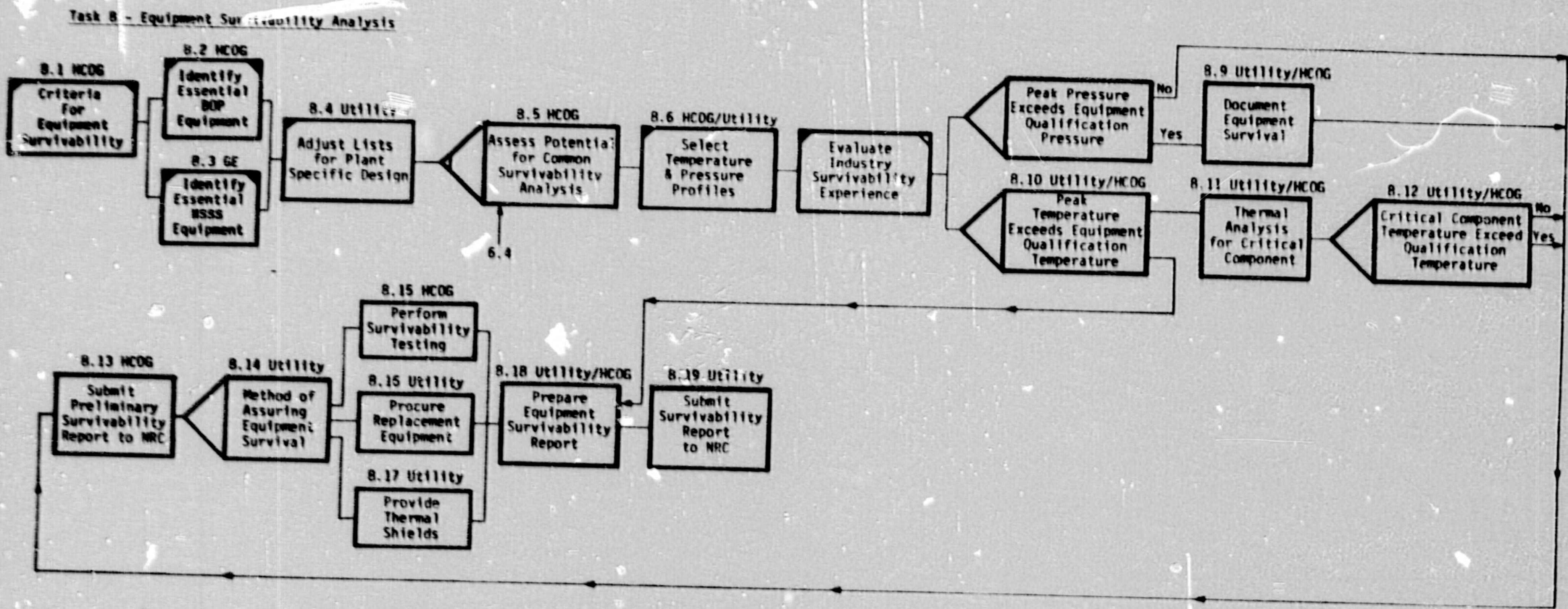


FIGURE 4-9


Task 8 - Equipment Survivability Analysis
8.1 HCOG
Criteria For Equipment Survivability
8.2 HCOG
Identify Essential BOP Equipment
8.3 GE
Identify Essential NSSS Equipment
8.4 Utility
Adjust Lists for Plant Specific Design
8.5 HCOG
Assess Potential for Common Survivability Analysis
6.4
8.6 HCOG/Utility
Select Temperature & Pressure Profiles
Evaluate Industry Survivability Experience
Peak Pressure Exceeds Equipment Qualification Pressure
No
Yes
8.9 Utility/HCOG
Document Equipment Survival
8.10 Utility/HCOG
Peak Temperature Exceeds Equipment Qualification Temperature
8.11 Utility/HCOG
Thermal Analysis for Critical Component
8.12 Utility/HCOG
Critical Component Temperature Exceed Qualification Temperature
No
Yes
8.15 HCOG
Perform Survivability Testing
8.13 HCOG
Submit Preliminary Survivability Report to NRC
8.14 Utility
Method of Assuring Equipment Survival
8.15 Utility
Procure Replacement Equipment
8.17 Utility
Provide Thermal Shields
8.18 Utility/HCOG
Prepare Equipment Survivability Report
8.19 Utility
Submit Survivability Report to NRC