

January 17, 1997

Mr. Nicholas J. Liparulo, Manager
Nuclear Safety and Regulatory Analysis
Nuclear and Advanced Technology Division
Westinghouse Electric Corporation
P.O. Box 355
Pittsburgh, Pennsylvania 15230

SUBJECT: COMMENTS ON AP600 MINIMUM INVENTORY OF FIXED-POSITION CONTROLS,
DISPLAYS, AND ALARMS

Dear Mr. Liparulo:

The Nuclear Regulatory Commission (NRC) has taken the position that a minimum inventory of fixed-position controls, displays, and alarms shall be defined for the AP600 control room and included as Tier 1 information in the AP600 design description and design certification documents. In a letter dated August 21, 1995, the NRC staff provided Westinghouse with guidance on establishing a minimum inventory of the fixed-position controls, displays and alarms.

In revision 9 to the AP600 standard safety analysis report (SSAR), Section 18.12, Westinghouse submitted its minimum inventory list based on implementation of the staff's guidance. The staff has reviewed the minimum inventory list and associated reference material and developed comments which are provided as an enclosure to this letter. The staff notes that while a comprehensive review was attempted, requests for additional controls, displays, and alarms for inclusion into the minimum inventory list may occur as the various NRC technical branches complete the AP600 review.

If you have any questions regarding this matter, you can contact me at (301) 415-1141.

Sincerely,

original signed by:

William C. Huffman, Project Manager
Standardization Project Directorate
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Docket No. 52-003

Enclosure: AP600 DSER Open Item
Status Update and Comments on
Minimum Inventory

cc w/enclosure: See next page

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Mr. Nicholas J. Liparulo
Westinghouse Electric Corporation

Docket No. 52-003
AP600

cc: Mr. B. A. McIntyre
Advanced Plant Safety & Licensing
Westinghouse Electric Corporation
Energy Systems Business Unit
P.O. Box 355
Pittsburgh, PA 15230

Mr. Ronald Simard, Director
Advanced Reactor Programs
Nuclear Energy Institute
1776 Eye Street, N.W.
Suite 300
Washington, DC 20006-3706

Mr. John C. Butler
Advanced Plant Safety & Licensing
Westinghouse Electric Corporation
Energy Systems Business Unit
Box 355
Pittsburgh, PA 15230

Ms. Lynn Connor
Doc-Search Associates
Post Office Box 34
Cabin John, MD 20818

Mr. M. D. Beaumont
Nuclear and Advanced Technology Division
Westinghouse Electric Corporation
One Montrose Metro
11921 Rockville Pike
Suite 350
Rockville, MD 20852

Mr. James E. Quinn, Projects Manager
LMR and SBWR Programs
GE Nuclear Energy
175 Curtner Avenue, M/C 165
San Jose, CA 95125

Mr. Sterling Franks
U.S. Department of Energy
NE-50
19901 Germantown Road
Germantown, MD 20874

Mr. Robert H. Buchholz
GE Nuclear Energy
175 Curtner Avenue, MC-781
San Jose, CA 95125

Barton Z. Cowan, Esq.
Eckert Seamans Cherin & Mellott
600 Grant Street 42nd Floor
Pittsburgh, PA 15219

Mr. S. M. Modro
Nuclear Systems Analysis Technologies
Lockheed Idaho Technologies Company
Post Office Box 1625
Idaho Falls, ID 83415

Mr. Ed Rodwell, Manager
PWR Design Certification
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, CA 94303

Mr. Frank A. Ross
Engineer
U.S. Department of Energy, NE-42
Office of LWR Safety and Technology
19901 Germantown Road
Germantown, MD 20874

Mr. Charles Thompson, Nuclear
AP600 Certification
NE-50
19901 Germantown Road
Germantown, MD 20874

Enclosure

AP600 DSER Open Item Status Update and Comments on Minimum Inventory

The staff RAI question Q620.50 dated April 29, 1993, and DSER open item 18.12.3-1, requested Westinghouse to develop a minimum inventory of fixed-position controls, displays, and alarms, (CDAs) based on a detailed Operational Sequence Analyses (OSAs). Westinghouse response was that the various analyses to be performed in support of the AP600 design will determine need for (CDAs) and that a minimum inventory had not been developed to date. Subsequently, in a meeting on February 2, 1995, Westinghouse provided the staff with a draft proposal on the minimum inventory process. Based on that discussion, the staff and Westinghouse continued dialog to determine the scope of the minimum inventory. The staff provided Westinghouse its position on the development of a minimum inventory in a letter from the NRC to Westinghouse, dated August 21, 1995, which was followed up by various conference calls between the staff and Westinghouse. To address the staff's position, Westinghouse submitted SSAR Section 18.12 (Revision 9), dated August 9, 1996, "Displays, Alarms, and Controls," subsequently revised to SSAR Section 18.12, "Inventory," (Revision 10) which provided a description of the minimum inventory development process, including a proposed list of CDAs comprising the inventory.

The following is an overview of the status of the results of the staff's review.

Open Item (OITS#, DSER#, RAI#)

Current Status

2044, 18.12.3-1, RAI Q620.50 Minimum Inventory

Action W

This open item was evaluated using the following subitems from the staff's DSER evaluation. The subitems and current status of each follows.

Subitem

Current Status

- | | |
|--|-----------------------|
| 1. Scope of the Minimum Inventory | Resolved |
| 2. Development of the Minimum Inventory | Action W ¹ |
| 3. Consideration of Operator Tasks (including PRA actions) | Action W ¹ |
| 4. HFE Input | Resolved |
| 5. Task Analysis (input to Minimum Inventory Development) | Resolved ² |

Development of the minimum inventory also includes defining and identifying a minimum inventory of controls, displays, and alarms (though not necessarily fixed position) to permit execution of the Remote Shutdown Workstation (RSW) operator tasks required to place and maintain the plant in a shutdown condition. Westinghouse has not addressed this area. This subitem and its current status are as follows:

Subitem

Current Status

6. Development of the RSW Minimum Inventory

Action W¹

¹Requires final review by NRC technical branches

²Reference DSER Section 18.5, Element 4, Task Analysis, Criterion #6

The Minimum Inventory open item will be satisfied when all the above subitems are resolved, the SSAR is revised acceptably, and appropriate ITAAC have been reviewed and accepted by the staff.

18.12 Minimum Inventory

As part of the general resolution of the lack of control room detail, the staff requested that applicants for design certification identify the minimum group of fixed-position controls, displays, and alarms that are required for transient and accident mitigation. In RAI Q620.50, the staff made this request concerning the AP600 design. The AP600 minimum inventory should be based on the AP600 ERGs, and the important operator actions derived from the PRA analysis. The information regarding the minimum inventory for AP600 is contained in the SSAR sections 7.5 and 18.12.

18.12.1 Objectives

The objective of this review is to ensure that analysis of the AP600 ERGs and the important operator actions specified as a result of the PRA analysis result in an acceptable minimum inventory of fixed-position controls, displays, and alarms for transient and accident mitigation.

18.12.2 Methodology

18.12.2.1 Material Reviewed

The staff reviewed the following material:

Westinghouse's response to RAI Q620.50, dated April 29, 1993
AP600 SSAR sections 7.5 and 18.12, Rev. 9
AP600 Emergency Response Guidelines, Rev. 2, August, 1996
AP600 Emergency Response Guidelines Background Documents, Rev. 2, August, 1996
List of AP600 critical actions contained in Rev. 1 of WCAP-14651, "Integration of Human Reliability Analysis with Human Factors Engineering Design Implementation Plan"

18.12.2.2 Technical Basis

The review was focused on evaluating the Westinghouse submitted material to ensure that proposed methodology met the overall intent of the staff request for a minimum inventory and that it was properly carried out by Westinghouse. Regulatory Guide 1.97, Rev. 3, May, 1983, was used to support the identification of minimum inventory instrumentation.

18.12.3 Results

1: Scope of Minimum Inventory

Criterion: The inventory should provide criteria that define a reasonable minimum set of fixed-position controls, displays, and alarms to adequately implement the emergency response guidelines (ERGs) for the AP600 design, account for the critical operator actions identified in the AP600 PRA, and mitigate transients and accidents associated with the (ERGs) and the PRA sensitivity study results.

DSER Evaluation: The staff cannot complete its evaluation of this criterion because Westinghouse has not defined a minimum inventory for the AP600 design. Westinghouse should submit an acceptable minimum inventory of fixed-position controls, displays, and alarms for transient mitigation. This is Open Item 18.12.3-1. This is also addressed under Criterion 6, "Minimum Inventory," in Section 18.5.3 of the DSER, and in the following Criteria 2 through 4.

Proposed Resolution: With Rev. 9 of the SSAR Westinghouse has submitted their methodology for the determination of the minimum inventory, as well as the results of the method. This is contained in Sections 7.5 and 18.12 of the SSAR. The AP600 is designed such that the primary controls, displays, and alarms are computer-based and "soft." Soft controls and displays are ones that are software-defined and can be changed to perform different functions. Their locations are not dedicated as are hardware controls and displays. The basis for this design choice is described and justified in Chapter 18 of the SSAR. It is based upon a combination of operating experience, research, and testing.

In addition to the soft controls and displays, Westinghouse has committed to providing a minimum set or inventory of dedicated or fixed-position instrumentation. Per Section 18.2.2 of the SSAR, this minimum inventory is used to monitor the status of critical safety functions (CSFs) and to manually actuate the safety-related systems that achieve these CSFs, and to establish and maintain safe shutdown conditions. These fixed-position controls, displays, and alarms are available at a fixed location. They are continuously available, but not necessarily continuously displayed to the operator. This is an acceptable approach.

In SSR section 18.12.2, Westinghouse describes the characteristics which they used to develop the minimum inventory. The five characteristics are:

- (1). Regulatory Guide 1.97 Types A, B, and C, Category 1 instrumentation.
- (2). Dedicated controls for manual safety-related system actuation (reactor trip, turbine trip, and engineered safety feature actuation).
- (3). Controls, displays, and alarms required to perform critical manual actions as identified from the PRA analysis.
- (4). Alarms provided for operator use in performing safety functions to respond to design basis events for which there is no automatically-actuated safety function.
- (5). Controls, displays, and alarms necessary to maintain the critical safety functions and safe shutdown conditions.

These characteristics address a reasonable minimum set of fixed-position controls, displays, and alarms for the minimum inventory. Each of these characteristics is discussed in more detail in the SSAR and are evaluated under subitem 2 below. The staff considers this subitem of Minimum Inventory satisfied and this part of the open item is resolved.

STATUS OF SUBITEM: RESOLVED

2: Development of Actual Items in the Minimum Inventory

Criterion: The development of actual items in the minimum inventory should include an acceptable set of controls, displays, and alarms developed from the defined scope and criteria of the above Criterion 1. It should appropriately address required operator actions in the emergency procedures or procedure guidelines.

DSEER Evaluation: The staff cannot complete its evaluation of this criterion because Westinghouse has not defined a minimum inventory for the AP600 design. Westinghouse should describe the technical basis for the minimum inventory. This is part of Open Item 18.12.3-1.

Proposed Resolution: As noted in subitem 1 above, Westinghouse has described five characteristics for defining the minimum inventory. These five characteristics are evaluated here.

(1). Regulatory Guide 1.97 Types A, B, and C, Category 1 instrumentation.

RG 1.97 defines a method for the determination of plant variables to be monitored by control room operators, and for the definition of the appropriate instrumentation to be used for those variables. The criteria of the RG are separated into three categories that provide a graded approach to requirements depending on the importance to safety of the measurement of a specific variable. Category 1 provides the most stringent requirements and is intended for key variables. Thus, the limitation to Category 1 here is appropriate.

Type A variables provide primary information needed to permit the operators to take specified manual actions for which there are no automatic controls and that are required for safety systems to perform their safety function for design basis events. Due to the passive nature of the AP600 and the specific systems design, there are no specific, preplanned, manual actions of this nature. Thus, there are no Type A variables for AP600.

Type B variables are defined in SSAR Section 7.5.3.2, Table 7.5-5, and SSAR Section 18.12.2. They are variables that provide information to the main control room operators to assess the process of accomplishing or maintaining the six critical safety functions in the emergency response guidelines (ERGs). Table 7.5-5 lists the Type B variables for AP600. Table 18.12.2-1 lists the minimum inventory and has a column that tells if the instrument is based upon a Type B or Type C variable. The six critical safety function status trees of the ERGs (AF-0.1 through AF-0.6) were reviewed to ensure that all Type B variables needed by the operators were included in Tables 7.5-5 and 18.12.2-1. RG 1.97, Table 3 provides a list of PWR Type B variables, which was compared to the Type B variables of AP600. Also Table 7.5-5 was compared with Table 18.12.2-1 to ensure that all identified Category 1, Type B variables had been transferred over to the minimum inventory list. With the exception of the items noted below, no discrepancies were identified.

It was noted that for each of the Type B variables Westinghouse has included a

display in SSAR Table 18.12.2-1, but has not included any alarms. It is not appropriate to exclude alarms. Alarms corresponding to the parameter values in the CSF status trees would be appropriate. Further, the following variables appeared to be missing from SSAR Tables 7.5-5 or 18.12.2-1.

- ERG AF-0.1 contains power range power %, intermediate range startup rate (SUR), and source range SUR. RG 1.97 calls for monitoring neutron flux from 10^{-6} % to 100 %. The Tables in 7 & 18 only mention neutron flux and do not address the range or include SUR.
- AF-0.3 contains steam generator (SG) narrow range level, SG pressure, and total feedwater flow. These are not in the Tables in SSAR Sections 7.5 or 18.2

Additionally, SG wide range level, appears to have been classified as a Category 2 variable, in the SSAR Section 7.5, and not category 1 as recommended in RG 1.97, without adequate justification. The staff also noted that only one channel is required per steam generator rather than the usual two per steam generator. The staff also needs to know if the indication channel is fed from the trip channel.

- AF-0.4 contains RCS cooldown rate and ρ_c compared to a limit, based on RCS pressure. The Tables in SSAR Sections 7.5 and 18.2 do not contain any provision for determining the rate or the comparison to the varying temperature/pressure limit. These parameters can very easily be developed into integrated displays with the computer-based instrumentation system of AP600.
- AF-0.5 lists containment radiation level. This variable is missing from Table 7.5-5, but is listed in Table 18.12.2-1.
- AF-0.6 contains a requirement to monitor pressurizer (PZR) level and PZR level behavior. Both tables contain PZR level, but neither has any mention of instrumentation related to the time-dependent behavior of PZR level.
- RG 1.97 lists containment isolation valve (CIV) position. However, SSAR Table 7.5-5 inappropriately limits CIV position to remotely operated CIVs. SSAR Table 18.12.2-1 does not limit its coverage to remotely operated CIVs.

In summary the coverage in the SSAR appears incomplete with respect to the Type B variables.

Type C variables are defined in SSAR Section 7.5.3.3, Table 7.5-6, and SSAR Section 18.12.2. They are variables that provide the control room operators with information to monitor the potential for breach or actual gross breach of: incore fuel cladding, RCS boundary, or containment boundary. Type C variables are listed in SSAR Table 7.5-6. SSAR Table 18.12.2-1 lists the minimum inventory and has a column that identifies if the instrument is based upon a Type B or Type C variable. The six CSF status trees of the ERGs (AF-0.1 through AF-0.6) were reviewed to ensure that all Type C variables needed by the operators were included in SSAR Tables 7.5-5 and 18.12.2-1. RG 1.97, Table 3 provides a list of PWR Type C variables, which was compared to the Type C variables of AP600. Also SSAR Table 7.5-6 was compared with SSAR Table 18.12.2-1 to ensure that all identified Category 1, Type C variables had been transferred over to the minimum inventory list.

As with the Type B variables, it was noted that, for each of the Type C variables, Westinghouse has included a display in SSAR Table 18.12.2-1, but has included no alarms. It does not appear appropriate to exclude alarms.

The only additional discrepancy noted for Type C variables (beyond those noted for Type B variables above) is based on RG 1.97, which calls for a measure of the radioactivity concentration or radiation level in the circulating primary coolant. This is not contained in either SSAR Table 7.5-5 or 18.12.2-1.

- (2). Dedicated controls for manual safety-related system actuation (reactor trip, turbine trip, and engineered safety feature actuation).

SSAR Section 18.12.2 states that the selection criteria for AP600 minimum inventory include dedicated, fixed position controls to manually initiate system-level actuation signals for the safety-related systems and components that are used to achieve CSFs. SSAR Table 3.2-3 was reviewed to determine the list of safety-related systems. This was then compared with the manual actuation controls listed in SSAR Table 18.12.2-1 for the minimum inventory. One safety-related system was noted to be missing: the main control room emergency habitability system (VES). VES is used to ensure that the control room operators survive in the event that normal control room ventilation is unavailable and thus indirectly addresses all six CSFs. Westinghouse should address what additional dedicated controls need to be added for this system.

- (3). Controls, displays, and alarms required to perform critical manual actions as identified from the PRA analysis.

Westinghouse notes in SSAR Section 18.12.2 that fixed position controls, displays and alarms to support the critical actions will be included in the minimum inventory. SSAR Section 18.7 references WCAP-14651, "Integration of Human Reliability Analysis with Human Factors Engineering Design Implementation Plan," Rev. 1, which notes that there are no critical actions for AP600. The staff evaluation of SSAR Section 18.7 and WCAP-14651, discusses the issue of the selection of critical operator actions based upon the AP600 PRA and notes that the threshold criteria for selection is unreasonably high. However, since Westinghouse also defines risk-important actions and uses them for other portions of the control room design (where critical actions were intended to be used), the staff has accepted the Westinghouse position. It should be noted that it is the staff's understanding that, although Westinghouse has not identified any critical operator tasks based on preliminary results from PRA studies completed in 1996, as PRA studies are completed and/or updated, critical operator tasks may be identified. Although the staff has accepted the Westinghouse criteria for defining critical operator tasks and risk-important tasks, the high threshold used by Westinghouse to define critical action selection has eliminated any entries to the minimum inventory that may be judged important based on operating experience and engineering judgement. In particular, the staff considers the manual actuation of ADS a very important action, whether it is considered a critical task or risk-important task by Westinghouse is not pertinent to the staff's assessment of its importance. Manual actuation of the ADS is based on level in the CMT reaching 67% and the ADS not actuating automatically. Consequently, CMT level is a key parameter needed to judge the necessity for an operator to manually actuate ADS. The staff

believes that CMT level should be included in the Minimum Inventory list.

- (4). Alarms provided for operator use in performing safety functions to respond to design basis events for which there is no automatically-actuated safety function.

As noted in the discussion under (1) above, due to the passive nature of the AP600 and the specific systems design, there are no preplanned, manual actions required for safety systems to perform their safety function for design basis events. Thus, since there are no operator actions of the type noted in (1), there are no alarms required to alert the operators to take the actions.

- (5). Controls, displays, and alarms necessary to maintain the critical safety functions and safe shutdown conditions.

With regard to the CDAs necessary to maintain the CSFs, these would be the same ones identified in (1) above, based upon the CSF Status Trees of the ERGs. Thus, the same discrepancies identified in (1) pertain here also.

With regard to CDAs to maintain the CSFs and safe shutdown conditions, the discussions under (2), (3) and (4) above indicate that Westinghouse has not included CDAs in the minimum inventory. If one were to go beyond single failure and use the ERG Functional Restoration Guidelines, which are entered from the CSF Status Trees, then additional controls would be obtained. However, this would add many more dedicated CDAs than appears appropriate in the highly computerized AP600 control room. If required, this added number of fixed controls, may actually be counterproductive to safety, due to creating requirements that are not appropriately integrated into the overall human factors engineering of the control room.

The Westinghouse ERGs also define a Critical Safety Function associated with shutdown conditions. While the Westinghouse criterion refers to safe shutdown, the staff considers this criterion applicable to all shutdown conditions. With regard to the controls, displays, and alarms necessary to maintain shutdown conditions, the ERG Shutdown Safety Status Tree was reviewed to determine if all required items to implement the Tree were on the minimum inventory list. The following items from the Shutdown Safety Status Tree were not in the minimum inventory list:

- RCS hot leg level
- Indication of RNS in service
- Alarm for nuclear flux doubling
- Display to tell if RCS pressure/temperature meet the cold overpressure limits
- Alarm/indication that RCS temperature has changed by more than 5 degrees in the last 10 minutes

In addition, the ability to control the normal residual heat removal system (RNS) appears to be essential to maintain the plant in cold shutdown. RNS is used to assist in achieving the CSF's of core cooling, heat sink, and RCS inventory in cold shutdown conditions. Westinghouse should define the minimum RNS CDAs that should be part of the minimum inventory.

In summary, the five characteristics used by Westinghouse to define minimum inventory were reviewed. Characteristic (4) was found to be satisfactorily addressed. Characteristics (1), (2), (3) and (5) were found to be unsatisfactory, as discussed above. Thus, this subitem remains open.

STATUS OF SUBITEM: ACTION W

3: Consideration of Operator Tasks

Criterion: An inventory of fixed-position controls, displays, and alarms necessary to permit execution of the operator tasks to place and maintain the plant in a safe-shutdown condition should be identified.

DSER Evaluation: The staff cannot complete its evaluation of this criterion because Westinghouse has not defined a minimum inventory for the AP600 design. Westinghouse should describe how an inventory will be identified of fixed-position controls, displays, and alarms necessary to permit execution of the operator tasks to place and maintain the plant in a safe-shutdown condition. This is part of Open Item 18.12.3-1.

Proposed Resolution: The characteristics established by Westinghouse for selection of minimum inventory items reviewed under subitems 1 and 2 above, address operator actions or tasks needed to maintain critical safety functions and safe shutdown conditions. Thus, the inventory description is adequate to address this subitem also. However, as noted in the review of subitem 2 above, selecting the actual inventory items was not adequately implemented. Thus, pending the resolution of subitem 2 issues, this subitem is also still open.

STATUS OF SUBITEM: ACTION W

4: HFE Input

Criterion: The inventory contains a list of key minimum displays, controls, and alarms necessary to carry out operator actions associated with the ERGs. The applicant will also need to identify and further define additional detailed characteristics of these controls, displays, and alarms (e.g., ranges, scales, physical dimensions, and actual information presentation) during the detailed task analysis and HSI design efforts. The HFE design process should provide adequate assurance that these detailed characteristics will be defined and implemented.

DSER Evaluation: The staff cannot complete its evaluation of this criterion because Westinghouse has not defined a minimum inventory for the AP600 design. Westinghouse should describe how additional detailed characteristics of these controls, displays, and alarms (e.g., ranges, scales, physical dimensions, and actual information presentation) will be identified, defined, and implemented. This is part of Open Item 18.12.3-1.

Proposed Resolution: The commitments provided in SSAR Sections 18.5, 18.8, 18.11 that address Task Analysis, Human System Interface (HSI) Design, and HSI Design Test Program (including verification and validation) provide an acceptable assurance that

these additional detailed characteristics of the controls, displays and alarms will be defined, designed, tested, and implemented. The detailed review of these sections of the SSAR is provided elsewhere. The staff considers this subitem of Minimum Inventory satisfied.

STATUS OF SUBITEM: RESOLVED

5: Task Analysis Input Into Minimum Inventory
(DSER Section 18.5, Element 4, Task Analysis, Criterion #6)

Criterion: The task analysis results should be used to define a minimum inventory of controls, displays, and alarms necessary to perform crew tasks based upon both task and I&C requirements.

DSER Evaluation: This item is addressed under Criterion 1, "Minimum Inventory," in Section 18.12 of this [DSER] report. Westinghouse should describe how the task analysis will define a minimum inventory of alarms, displays, and controls necessary to perform crew tasks. This is addressed under Open Item 18.12.3-1.

Proposed Resolution: Westinghouse has defined a method and criteria that will be used to define the minimum inventory. These are delineated in SSAR Section 18.12 and have been previously reviewed in Section 18.12. The method does not directly use the Task Analyses, but provides an acceptable alternative that uses a combination of Regulatory Guide 1.97, the design features of the AP600, and the emergency response guidelines.

SSAR (Revision 9) Section 18.5.2, Task Analysis Implementation Plan, indicates that the Function-based Task Analysis (FBTA) is used as a completeness check on the availability of needed indications, parameters, and controls (p.18.5-2). The SSAR also indicates that the OSAs will provide information on the inventory of alarms, controls, and parameters needed to perform sequences selected for analysis which include those addressed in the discussion of Task Analysis Criterion 1, Scope, discussed in Section 18.5.

Based on this information, the DSER Criterion 6, for Task Analysis is satisfied.

The staff considers this subitem of Minimum Inventory satisfied.

STATUS OF SUBITEM: RESOLVED

6: Development of the Remote Work Station Minimum Inventory
(SSAR, Section 7.4.3.1.1, Remote Shutdown Workstation)

In conjunction with the effort by Westinghouse to develop a main control room (MCR) minimum inventory of controls, displays, and alarms (CDAs) for use in the mitigation of transient and accidents, the staff requested Westinghouse provide a list of CDAs

which would be available at the Remote Shutdown Workstation (RSW) for use in establishing and maintaining shutdown conditions in the event the MCR was uninhabitable. The staff does not consider it necessary that any RSW CDAs be fixed-position. However, a minimum inventory of CDAs accessible from the RSW should be well described in the SSAR. The issue was discussed during a number of conference calls between the staff and Westinghouse, dated September 12, 1995, April 17, 1996, and July 11, 1996. To address the staff's request, Westinghouse submitted SSAR, Rev.9, Section 18.12, dated August 9, 1996, "Displays, Alarms, and Controls," subsequently revised to SSAR Section 18.12, "Inventory," (Revision 10), Section 7.4 (Revision 5), "Systems Required for Safe Shutdown," dated February 29, 1996, and Section 7.5 (Revision 8), "Safety-Related Display Information," dated June 19, 1996. These documents provided descriptions of the systems required for safe shutdown and a table of post-accident monitoring system information and a summary of RG 1.97 variables by type and category.

The staff cannot complete its evaluation of this issue because Westinghouse has not defined a list of CDAs which would be available at the RSW. Westinghouse should describe how the RSW minimum inventory is developed and submit an acceptable list of CDAs for use at the RSW.

Based on this information, this subitem is unresolved and remains part of Item 18.12.3-1.

STATUS OF SUBITEM: ACTION W

18.12.4 Conclusions

Westinghouse has defined a minimum inventory for the AP600 design, however there are some unresolved details, as noted above. DSER Open Item 18.12.3-1 thus remains open. These unresolved details must be acceptably addressed before the staff can complete its review of this area.