File 6153
80-555
#5

AMERICAN NUCLEAR SOCIETY
STANDARDS COMMITTEE

November 20, 1979

Headquarters:
555 North Kensington Avenue
LaGrange Park, Illinois 60525 USA
Telephone 312/352-6611
Telecopy 312/352-0499
Telex 254635

To: Members of the American Nuclear Society Nuclear Power Plant Standards Committee (NUPPSCO)

Subject: Review of ANS-3.5

Gentlemen:

I am enclosing a draft of the revision of ANS-3.5-1979, "Nuclear Power Plant Simulators for Use in Operator Training," for your REVIEW. ANS-3 recently reviewed this material during its early November meeting (ANS-3 comments resolutions are not included in this draft), and now forwards it to you for comment and discussion at our December meeting.

It is recognized that the time for review is short. Therefore, please bring your comments with you to the December meeting so they can be conveyed to Jim Green. Be prepared to discuss your substantive comments during our review. If you cannot attend the meeting, please send copies of your comments to Jim Green and N. S. Elliot (see address below), not later than December 27, 1979.

Sincerely, ← Due 12/21/79

Marilyn

Mrs. Marilyn D. Weber
Secretary, NUPPSCO

N. S. Elliot
Babcock & Wilcox
P. O. Box 1260
Lynchburg, VA 24505

MDW:eja

encl.

cc: R. A. Bari, NRSD Liaison) w/o encl.
N. S. Elliot)

Jack Wells

The [illegible] significantly improved over the original. [illegible] numerous exceptions. [illegible] is needed. [illegible] 12/27/79 — [illegible] Jerry [illegible] NRR [illegible] NRC comments [illegible]

2 Wiebe
Good report
Note questions
3 File

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

NOV 19 1979

ED,
Here are partial answers to your questions. Additional supporting data for ORNL/Sargo's recommendations will be in their report.
JSW

MEMORANDUM FOR: E. C. Wenzinger, Chief
Reactor Systems Standards Branch
Division of Engineering Standards
Office of Standards Development

FROM: J. S. WIEBE
Reactor Systems Standards Branch
Division of Engineering Standards
Office of Standards Development

SUBJECT: MEETING ON SIMULATOR TRAINING STUDY

The conclusions and results of the study conducted by Oak Ridge National Laboratory (ORNL)/Memphis State University (MSU), to review "Simulator Training Practices" was presented at a meeting in the East-West Towers on Wednesday, November 14, 1979. Paul M. Haas, ORNL Program Manager, conducted the presentation.

The primary goals of the study were: (1) Assess capabilities of current simulators for training in abnormal/emergency events; (2) Assess current use of simulators in training programs; (3) Make recommendations for improvement of simulators and their use in Training.

The assessment of the capabilities of training simulators showed that: (1) Training features are considered generally adequate for training but their use is very much dependent upon the instructors expertise and ingenuity; (2) Initialization conditions are extremely flexible with the use of specific features such as freeze, backtrack or snapshot. The capability to initiate with off-normal conditions was said to exist but was not demonstrated to ORNL/MSU. The current capability was considered adequate for training needs; (3) The number of systems simulated and the accuracy of simulation is limited by current computer capability. A significant increase in number of systems or accuracy would require an order of magnitude cost of the computer. Improvements are necessary in the math models to improve real time simulation; (4) The malfunctions simulated showed a significant site-to-site variation. There is no consistent procedure or research base for selecting them. Compounded abnormalities and multiple failures are possible; (5) Nuclear simulators are making reasonable use of state-of-the-art computers.

Yes, to train the operator to check for and correct initial conditions prior to commencing an evolution. JSW

Do you feel this is essential?

improve beyond what level?

1. Whose conc!?
2. Basis?

ORNL's conclusion based on discussions with Simulator vendors and computer vendors

This needs more research and/or investigation. The problem lies in the speed of the computer and the ~~requirement~~ use of math models to determine (calculate?) the required output to provide the correct simulation. As the simulator is designed to more closely (accurately) simulate the plant, the time taken to determine the output increases to the extent that the output cannot be produced in real time. Singer has done work in this area but their math models change as the parameters change. This may have an impact on ability to initiate with off-normal conditions or respond to (over)

How much of a problem is this?

8001220547
PDR

The assessment of current use of simulators in training programs showed that (1) Simulator usage (time and scope) is relatively limited in nuclear industry; (2) There is limited evidence of feedback of operating experience into simulator training programs; (3) About 30% of simulator training is in emergency/abnormal events.

The major recommendations were:

1. A task analysis and comprehensive study of training goals should be undertaken to develop specific goal-oriented training objectives and establish best use of simulators, necessary exercises to develop skills ✓

2. Develop a consistent procedure for selection of malfunctions. This procedure can be used to:

   - Evaluate existing simulators, training programs
   - Evaluate, develop standards or regulatory requirements for simulation
   - Develop improved simulators, programs ✓

3. Use results of 1 and 2 to specify requirements for site-specific simulation. It is opinion of MSU/CNS that site-specific simulation is necessary for hot license and requalification, probably not for cold license. why difference?

4. A consistent framework of regulatory policy associated with the entire training process should be developed to address weaknesses noted in this and other NRC, government and industry studies. Specifically emphasized from this study:

   - Minimum qualifications for, possibly certification of instructors
   - Requirements for verification of fidelity of simulators
   - verification of updating, use of reference data
   - procedures for assuring incorporation of operating experience. ✓

5. Research should be carried out in following areas:

   - Human factors analysis of control room tasks; training needs; objectives ✓
   - Assessment, verification of effectiveness of simulator training for skills in abnormal events ✓
   - Math Modeling ✓

show to Medeiros

The study revealed that a major problem with simulators and related training was the lack of a consistent procedure for determining which malfunctions to include within the constraints of the training program. D. Wayne Jones presented a possible solution to the problem based on a detailed study of LERs (Operating experience), assessment of direct safety impact of malfunctions, assessment of plant availability impact of malfunctions, and assessment of potential as an accident precursor. The procedure ranks the malfunctions by the above four factors and the priority for including them

in the training program depends on their ranking. It was acknowledged that the procedure needs a more vigorous method for ranking and identification and additional judgment on the relative weighting of the factors.

An advance copy of the study report will be available during the first week in December.

J S Wiebe

J. S. Wiebe
Reactor Systems Standards Branch
Division of Engineering Standards
Office of Standards Development

80-555
#5

U. S. NUCLEAR REGULATORY COMMISSION

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	D. F. SULLIVAN	P-722	
	C. E. TURNER	314	
REMARKS: ~~Wiebe~~		①	

I assume these ideas are being considered/incorporated into the reg guide endorsing 3.5

Ed

☐ As Requested ☐ See Me ☐ Note and Return
☐ Correction ☐ Approval/Signature ☐ Per Conversation
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NRC Form 17A (11-75) U. S. NUCLEAR REGULATORY COMMISSION

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REMARKS:

J. Wiebe - retain for info

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Signature of _____

FROM (Name)	OFFICE	DATE
		PHONE

[illegible] FEDERAL AVIATION ADMINISTRATION

[illegible] Aviation Administration

14 CFR Parts 61 and 121

[Docket No. 19758; Notice No. 79-18]

Plan to Permit Additional Flightcrew Training in Advanced Flight Training Simulators

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of Proposed Rule Making (NPRM).

SUMMARY: This NPRM proposes to permit expanded training, checking, and certification of flight crewmembers in advanced flight training simulators. This action will encourage operators to upgrade their simulators and perform a higher percentage of training in simulators so that the total scope of flightcrew training will be enhanced. The results of this action include substantially improved safety, fuel conservation, and a reduction of airport congestion. In addition, this action proposes a regulatory alternative which could result in significant cost savings for air carriers.

DATE: Comments must be received on or before January 14, 1980.

ADDRESS: Comments on this proposal may be mailed in duplicate to: Federal Aviation Administration, Office of the Chief Counsel, Attn: Rules Docket (AGC-24), Docket No. 19758; 800 Independence Avenue S.W., Washington, D.C. 20591; or be delivered in duplicate to: Room 916, 800 Independence Avenue S.W., Washington, D.C. 20591. Comments delivered must be marked: Docket No. 19758. Comments may be inspected at Room 916 between 8:30 and 5:00 p.m.

FOR FURTHER INFORMATION CONTACT: Mr. Raymond E. Ramakis, Regulatory Projects Branch (AVS-24), Safety Regulations Staff, Federal Aviation Administration, 800 Independence Avenue S.W., Washington, D.C. 20591; telephone (202) 755-8716.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to participate in the making of the proposed rule by submitting such written data, views, or arguments as they may desire. Communications should identify the regulatory docket or notice number and be submitted in duplicate to: Federal Aviation Administration, Office of the Chief Counsel, Attention: Rules Docket, AGC-24, 800 Independence Avenue S.W., Washington, D.C. 20591. All comments received on or before January 14, 1980, will be considered by the Administrator before taking action on the proposed rule. The proposals contained in this notice may be changed in the light of comments received. All comments submitted will be available, both before and after the closing date for comments, in the Rules Docket for examination by interested persons. A report summarizing each substantive public contact with FAA personnel concerned with this rule making will be filed in the docket.

Availability of NPRM's

Any person may obtain a copy of this Notice of Proposed Rule Making (NPRM) by submitting a request to the Federal Aviation Administration, Office of Public Affairs, Attention: Public Information Center, APA-430, 800 Independence Avenue S.W., Washington, D.C. 20591, or by calling (202) 426-8058. Communications must identify the notice number of this NPRM. Persons interested in being placed on a mailing list for future NPRM's should also request a copy of Advisory Circular No. 11-2, Notice of Proposed Rulemaking Distribution System.

Discussion of the Proposed Rule

Background

As the state-of-the-art in simulator technology advances, more effective use has been made of the aircraft simulator in training, checking, and certification of flight crewmembers. Simulators can provide more indepth training than can be accomplished in the aircraft with a very high percentage of transfer of learning to the aircraft. The desirability of good simulation is overwhelming. Its benefits to training include the following:

- Who can be trained?
  - Entire flightcrew
  - Individual flight crewmembers
- What can be trained?
  - Normal operations procedures
  - Abnormal operations procedures
  - Emergency procedures
  - Any weather condition
  - Any lighting condition
  - Any airport location
  - Training situations which would be impossible or unsafe to conduct in the aircraft, such as wind shear, blown tire on landing, etc.
- When can training occur?
  - 24 hours a day
  - Any day of the year
- Where can the training take place?
  - Any location that can house the simulator

All of this adds up to training flexibility with maximum safety. In addition, the use of simulators in lieu of the aircraft results in great cost reductions for the operator and achieves the benefit of fuel conservation and a decrease in airport noise.

During the last 25 years, as simulator technology has improved, changes to the Federal Aviation Regulations (FAR) were made to permit the increased use of simulators in air carrier training programs. FAA acknowledgment of the value of simulator training began in 1954 when air carriers were allowed to perform all but four proficiency maneuvers in a simulator. From this beginning, the FAA has continued to promote, evaluate, and regulate the use of simulation in aviation. In the late 1960's, visual attachments appeared on the market. Since that time, a breakthrough in computerization has permitted the development of computer-generated image (CGI) visual systems. In December 1973, FAR Amendments 61-62 and 121-108 were issued which allowed additional training in visual simulators. Because many training maneuvers, such as engine failure on takeoff and visual approaches, require visual cues to provide the necessary training, these amendments resulted in reducing aircraft flight training to approximately 1½ hours for an airline transport pilot certificate. The 1½ hours of actual flight time was necessary to train the pilot to land the aircraft from a visual and instrument approach and to become familiar with the feel of the aircraft prior to the FAA certification check. A 1978 amendment to § 121.439 of the FAR permitted a simulator approved for the landing maneuver to be substituted for the aircraft in a pilot recency of experience qualification. The landing maneuver approval program associated with this rule change and its associated simulator approval criteria constituted a significant step toward the optimum use of aircraft simulators in flight training and checking.

The FAA has historically found, however, that the quality of training simulation in the United States is directly proportional to the quality required for FAA training approval. Due to the cost of simulator upgrading, early simulators, which were approved for certain training maneuvers, were used in the industry long after simulator technology had outdated them. It became apparent to the FAA that simulator approval criteria had to develop along with simulator technology to ensure the highest level of flightcrew training. To facilitate this, the FAA has developed simulator approval criteria

which are as objective as possible and are designed to ensure that:

1. The simulator software is programed with data which accurately represent the aircraft, the flight environment, and the ground environment;

2. The simulator hardware accurately represents the aircraft, provides minimal electronic interference (noise) to the computer software, and provides a fast rate of transfer from input to output;

3. The motion system is smooth, responsive, and closely represents the onset motion cues of the aircraft; and

4. The visual system is responsive and the visual presentation is realistic.

The degree to which the approval criteria can ensure that these objectives are met will determine how closely the simulator represents the aircraft and the flight environment. The FAA has been seeking these objectives through a continuous program to upgrade flight training simulators. This program includes amending simulator approval criteria to reflect advancements in technology and encouraging industry investment in simulation by permitting more training and checking to be accomplished in more advanced simulators.

The FAA's recent program to upgrade and promote advanced simulation involves approval of simulators for the landing maneuver. This program would be extended to become Phase I of the FAA's Advanced Simulation Plan described in this notice. It is designed to allow landing and proficiency currency to be regained in a simulator rather than an aircraft if the simulator meets more stringent approval criteria. The landing maneuver approval program includes upgrading the total simulator as well as including ground effect and ground handling programing for better landing presentations. It also matches the performance of the simulator to that of the actual aircraft so that the previously required flight time could be eliminated in certain training areas. Advisory Circular 121-14B, Aircraft Simulator Evaluation and Approval, contains current guidance on the approval of simulators. With the development of this advisory circular, a national simulator evaluation team was formed to conduct all landing maneuver evaluations. This team of trained simulator evaluators was formed to provide standardization in the evaluation of both the objective and subjective simulator performance criteria. The program can be best described by looking at the major simulator components.

Simulator Software. Under the landing maneuver program, simulator software is evaluated by performing, in the simulator, over 30 static and dynamic tests which are contained in a specially prepared test guide. The tests are selected to ensure that the programing accurately represents the aircraft during each phase of flight and the ground and flight environments. Each test contained in the test guide should be based on, or verified with, actual aircraft flight test data. This specification is essential in that it objectively ties the simulator to a specific aircraft. A further specification for the evaluation is a multichannel recorder. It is used to record a time history of each test for later analysis and to serve as a permanent record against which recurrent simulator evaluations can be compared. The addition to the simulator approval process of actual flight test data verification and the use of a multichannel recorder has shown significant improvement in upgrading and standardizing flightcrew training simulators.

The flight test verification has encouraged the simulator and aircraft manufacturers to scrutinize the data currently available for simulator programing. This scrutiny has shown that some of the data in current simulators do not accurately reflect corresponding flight test data. When the landing maneuver approval program began, many areas of data were completely nonexistent, such as ground effect and most ground handling special effects. These data are important in presenting an accurate simulation of landing and ground maneuvers. Through data verification, the aircraft manufacturers have discovered ways to obtain such data and make them available for simulator programing. Data verification has also resulted in airlines demanding more complete and accurate data, useful in simulation, to be supplied by the aircraft manufacturers as part of new aircraft purchase agreements. The multichannel recorder requirement has provided the FAA with an objective tool for the initial evaluation of the simulator and for ensuring that changes are not made to the aerodynamic and ground handling programing without proper data verification. Correlation (within specified tolerances) of the multichannel time histories of an actual flight test and a simulator test is an objective approval specification which can be applied fairly and impartially from simulator to simulator.

Simulator Hardware. Under the landing maneuver program, simulator hardware is evaluated in a manner similar to the software program. The cockpit hardware is evaluated through functional checks of cockpit equipment. The interface between hardware and software is measured and recorded during the static portions of the software test. Simulator performance tolerances, however, have been tightened to closely match the simulator's performance to the typical performance of the aircraft. This also serves to increase the repeatability of simulator tests.

Simulator Motion System. Under the landing maneuver program, the simulator motion system is evaluated both objective and subjectively. Objectively, the motion system is put through a series of tests, such as a frequency response check, which are recorded and evaluated to determine the system's responsiveness and smoothness. The system is also subjectively evaluated to determine how accurately it represents the feel of the aircraft. As the need for ground handling and special motion effects increases, the need for a six-axis motion system also increases in order to provide a realistic simulation. A motion system which provides a realistic simulation of aircraft motion is an essential part of simulator training in air carrier aircraft. This is due to the response characteristics of air carrier aircraft to control inputs and the inherent physiological problems related to motion sensations. Without a motion system, the pilot would not experience the motion onset cues normally expected in the aircraft.

Simulator Visual System. Under the landing maneuver program, the simulator visual system is evaluated to determine its responsiveness and the realism of its visual presentation. The responsiveness can be accurately determined by recording the time between the time when a control input signal is sent to the simulator computer and the time when a visual system computer output signal is sent to the catholde ray tube (CRT). We have found that CGI visual system iteration rates of at least 30 picture updates per second with simulator computer response times from pilot input to picture movement of less than 300 milliseconds are necessary to produce a clear presentation which does not result in pilot-induced oscillations in air carrier aircraft simulators. Since the human eye may be able to detect movements with a delay of greater than 150 milliseconds, it is desirable to reduce simulator response times to 150 milliseconds.

The realism of the visual display is evaluated both objectively and subjectively. The objective evaluation is comprised of positioning the simulator at a known point in space and comparing what can be observed from

that point with a specific requirement. For example, at 5 miles from the approach end of a runway, the runway and taxiways should be recognizable; at 2 miles the red and green threshold lights should be recognizable; etc. The subjective evaluation consists of noting how realistic the visual scene appears. This includes the ability of the system to portray a specific airport environment such as runway 22L at John F. Kennedy International Airport, specific visual conditions such as patchy fog RVR 2400, and other effects such as the landing lights or the rotating beacon reflecting off the clouds when flying in the weather.

Because of the importance of visual systems, each advancement in the realism of the visual display enhances the total effectiveness of the simulator and brings it closer to the time of total simulator training and checking. By expanding the criteria for approving simulators in the landing maneuver approval program, the FAA has seen a dramatic improvement in the quality of the simulators upgraded to meet the criteria. From this experience and an analysis of FAA studies conducted under Exemption Nos. 2501 (captain upgrade training) and 2621 (transition training), the FAA has concluded that advanced simulation training is possible. Advanced simulation, however, will require even further expanded simulator approval criteria.

In looking toward the future and toward advanced training simulation, the FAA has had to consider the training requirements of the future and how the simulator should be designed to accomplish this training. National Transportation Safety Board (NTSB) Accident Statistics[1] show that 48.3 percent of all air carrier accidents are caused by or related to adverse weather conditions. Further, the number of accidents caused by crew coordination problems has remained about constant for the past 10 years. During the same time frame total accidents have decreased by approximately two-thirds. FAA therefore believes that training of the future should emphasize crew coordination and pilot judgement, and simulator training programs should require more realism in their presentation of both normal and abnormal flight conditions. Current training programs emphasize the accomplishment of specific flight maneuvers and operating procedures by individual flight crewmembers. For this type of training, simulators need only represent the aircraft in specific training environments and for specific ground and flight maneuvers. However, as training concepts shift toward a crew concept of training and checking, where training is needed in varying training environments such as those encountered in line operations, the simulators will need to be designed for more generalized use. The more generally applicable simulators will require substantial additional environment and aircraft performance programing, six degree motion systems, and visual systems which can accurately display varying times of day and weather conditions from rain and snow to clear and dry.

[1] NTSB Annual Review of Aircraft Accident Data, U.S. Air Carrier Operations 1977 report number NTSB-ARC-79-2.

Discussion

The FAA is considering rule making which will provide guidelines and a means for achieving nearly total flightcrew training, checking, and certification in advanced simulators. In addition to the creation of a new Appendix H to Part 121, amendments to § 61.157 of Part 61 and § 121.407 of Part 121 are being proposed. The amendments to § 61.157 and § 121.407 will permit expanded use of simulators in training, checking, and certification for operators who use an advanced flight training simulator as part of an approved Part 121 training program or its equivalent. The requirements for an advanced training simulator are outlined in a new Appendix H to Part 121. Appendix H outlines the FAA three-phase Advanced Simulation Plan and lists the simulator and visual requirements for each phase. The following presents a general analysis of the benefits of expanding the use of simulation through the Advanced Simulation Plan:

Safety. In the past few years significant developments in simulator technology have made it possible to realistically simulate a specific aircraft and its ground and flight environment. By taking advantage of the capabilities of state-of-the-art simulators, flightcrew training could be upgraded from a strictly maneuver/procedures-oriented program to a program where crewmembers can also gain experience in dealing with abnormal flight, system, and environmental situations. This can be illustrated by looking at current flightcrew training. Current flightcrew training is based on the maneuvers which have been historically conducted in the aircraft. These maneuvers include stalls, steep turns, instrument approaches, aircraft engine and system failures, etc. Since current training is based on what can be accomplished in an aircraft, the training has to be procedurally oriented and designed to avoid placing the aircraft in an unsafe condition. Simulators can provide this training and permit aircraft engine and system failures training to be conducted safely so that, for example, training in a critical-field-length engine failure on takeoff maneuver can be realistically conducted. Simulators have been designed, however, to provide the same types of manuever training that have been historically conducted in the aircraft and are not capable of providing improved types of training in different flight environments, such as thunderstorms, icy runways, etc. A review of NTSB accident statistics has shown that pilot error and adverse weather conditions are the primary causes of most air carrier accidents. This review has revealed that it is not the pilot's ability to control the aircraft or fly a specific maneuver but rather the ability of the crew to deal with the abnormal flight situation which causes the accidents. Improved training in advanced simulators could be the most significant means for reducing these types of accidents. Under the Advanced Simulation Plan, the simulators will have the capability to be programed to represent a full range of aircraft flight conditions as well as specific aircraft accidents in abnormal environmental conditions. In this way flightcrews could experience a far-ranging set of flight environments and malfunctions. This could assist the crew in making proper judgments when abnormal situations occur in flight. Safety could, therefore, be enhanced dramatically. Without upgrading simulators, upgrading training to this extent will be impossible.

Safety could also be greatly increased because advanced training simulators can provide training without the risk of aircraft training accidents. Since 1962 U.S. air carriers have experienced 67 training accidents of which 6 were fatal accidents. In the future, training accidents could be avoided through advanced simulation.

Energy Evaluation. As a result of information available to the FAA, it is estimated that 32,000,000 gallons of fuel could be saved per year if air carriers could use advanced flight training simulators in lieu of aircraft for transition and upgrade training. Over 65,000,000 gallons could be saved per year if the proposed advanced simulation plan were fully implemented. These figures are based on 1979 training and nonrevenue flight hours utilized by air carriers. Actual fuel savings will depend on the number of Part 121 and other operators who elect to upgrade their simulators.

Environmental. While it is impossible to accurately determine the environmental impact of the advanced simulation plan due to its permissive nature, it is certain that all impacts would be beneficial. Air carriers estimate that over 39,000 hours of flight training time in large turbojet aircraft will be logged during 1979. This training is almost always conducted at low altitudes near major metropolitan airports.

Economic. As a result of the economic and energy benefits which will result from this proposal, there is no economic burden imposed on the industry, the government, or the private sector by this action. This notice proposes a regulatory alternative which could result in economic savings for industry. This is consistent with Executive Order 12044. Economics do, however, play an important role in an operator's decision to upgrade its simulators according to the advanced simulation plan.

Basically, the operator must balance the cost of upgrading its simulators, including the value of the safety and training benefits of using advanced simulators, against the aircraft operating costs, time out of revenue service of the aircraft, aircraft scheduling and maintenance problems, etc. Cost involved in flying the aircraft vary from operator to operator depending, for example, on the type of aircraft involved, the number of crewmembers who require certain types of training, union contracts, and training base location. Costs for upgrading a simulator will also vary depending on the aircraft type and the condition of the simulator prior to upgrade. Over $35,000,000 per year could be saved by the U.S. air carriers in fuel costs alone under Phase III of the Advanced Simulation Plan.

The proposed rule will encourage simulator upgrade by permitting more training and checking in more advanced simulators. Therefore, each phase of the Appendix H Advanced Simulation Plan will have tighter simulator and visual requirements while permitting more training and checking to be conducted in a simulator. A simulator upgraded to the requirements specified in Appendix H is capable of providing the training indicated in that phase of the plan if the simulator training is accomplished as part of an FAA-approved training program.

The requirements set forth in Appendix H are in addition to the simulator approval requirements set forth in § 121.407. Each simulator which is used under Appendix H must be approved as a Phase I, II, or III simulator as appropriate. In order to obtain approval of the simulator for a specific phase, the following must be demonstrated to the satisfaction of the Administrator:

1. Documented proof of compliance with the appropriate simulator, visual system, and additional training requirements of Appendix H for the phase for which approval is requested and preceding phases.

2. An evaluation of the simulator to ensure that its ground, flight, and landing performance closely matches the type of aircraft simulated (Phase I approval tests).

3. An evaluation of the appropriate simulator and visual system requirements of the phase for which approval is requested and preceding phases.

Since an amendment to any portion of the simulator's programing can effect the other portions of the programing, it is important to evaluate the preceding requirements any time a simulator is upgraded to the next phase.

While the FAA acknowledges the need for some flexibility in making changes in the software programing, strict scrutiny of these changes is essential to ensure that the simulator retains its ability to precisely duplicate the aircraft's flight and ground characteristics. Therefore, the following procedure must be implemented to permit these changes without affecting the approval of an Appendix H simulator:

1. Twenty-one calendar days prior to making changes to the software programing of an Appendix H simulator, a complete list of planned changes that impact flight or ground dynamics, including dynamics related to the motion and visual systems, will be provided to the FAA office responsible for conducting the recurrent evaluation of that simulator.

2. The FAA office shall have 21 days in which to evaluate a planned change. If the FAA does not object within 21 calendar days, the operator may make the change.

3. Changes which might affect the approved simulator Phase I test guide must be tested by the operator in the simulator to determine the impact of the change.

4. Software changes actually installed must be summarized and provided to the FAA. Where the operator's test has shown a difference in simulator performance due to change, an amended copy of the test guide page which includes the new simulator test results must also be provided to update the FAA's copy of the test guide.

5. The FAA retains the option to examine supporting data and/or to flight check the simulator to ensure that the aerodynamic quality of the simulator has not been degraded by any change in software programing.

6. All requests for changes will be evaluated on the basis of the same criteria used in the initial approval of the simulator for Phase I, II, or III.

FAA recurrent evaluations of this simulator will consist primarily of tests selected from the Phase I test guide. The Phase I test guide and the multichannel recorder printout used in the initial Appendix H approval evaluation will be kept on file in the FAA office responsible for conducting the recurrent evaluation of that simulator. These documents will serve as a standard for recurrent evaluations and a record of the initial approval of that simulator for Phase I.

Because of the strict tolerances and other approval requirements of Appendix H simulators, the FAA also recognizes that the simulator can provide realistic training with certain nonessential items inoperative. Therefore, an operator is permitted to operate its simulator under the same conditions and limitations outlined in the simulated aircraft's minimum equipment list (MEL) as long as the inoperative equipment is repaired within 24 hours and the inoperative equipment permitted by the MEL is not specifically required for the training involved. A simulator visual system may be inoperative at one pilot position if a pilot is not receiving training in the position, but shall be operative at both pilot positions for Line Oriented Flight Training (LOFT).

The Advanced Simulation Plan will only apply to an operator who uses the simulator under an approved Part 121 training program or a certification training program used by an owner/operator which is equivalent to a Part 121 initial training program. The interim phase will only apply to Part 121 operators to permit the FAA to closely monitor the upgrade of air carrier simulators as part of the Advanced Simulation Plan. At the option of the Administrator, each pilot completing a flight check under Phase II or III may be observed by the FAA during at least one flight leg on the line which includes a takeoff and landing performed by that pilot.

One objective of the Advanced Simulation Plan is to issue the FAR Part 61 airline transport pilot (ATP) certificate at the successful completion of the appropriate simulator check. Another objective is to upgrade operators' simulator capabilities to present realistic training scenarios as abnormal and weather flight conditions which may be encountered during line

operations. Both objectives are essential to the plan.

The proposed Appendix H describes the specific training and checking permitted, the simulator requirements, the visual requirements, and the additional training requirements of each phase of the plan. The following discusses each phase of the plan in general.

Phase I—Simulator Landing Approval

Phase I is the current landing approval program. The training permitted under this phase is currently authorized for fully qualified air carrier pilots by FAR § 121.439 and through FAA exemptions. Phase I is designed to encourage operators to upgrade their older simulators to the greatest extent possible. Basic simulator approval guidance and specific simulator tolerances for Phase I simulators are contained in Advisory Circular 121-14B.

Phase II—Simulator Upgrade Program

Phase II is designed to provide new simulator training capabilities by expanding the ability of the simulator to portray the ground and flight environment and increasing the simulator's responsiveness. In addition to upgrading the simulator, a 4-hour LOFT course will be required after the appropriate Part 61 or 121 simulator check. This course must be approved by the Administrator and be designed to prepare the flight crewmember for line operations. At the completion of a Part 61, Appendix A, check in the simulator, the appropriate aircraft rating will be issued. Instructors used in these training programs must be highly experienced. A minimum of 1-year's experience on the line in an aircraft in the same group in which they are instructing and active participation in a regularly scheduled line flying program are required. Pilots who participate in the Phase II program are also highly experienced. they must be fully qualified pilots in a similar aircraft and meet the requirements of Appendix H prior to being eligible for Phase II certification.

Phase II A—Interim Simulator Upgrade Program for Part 121 Operators

Under Phase II A, any Part 121 operator may conduct Phase II training for 3½ years in a simulator approved for the landing maneuver under Phase I, provided the operator meets the additional requirements set forth in Appendix H and submits a plan acceptable to the Administrator to upgrade its simulator(s) to meet the Phase II standards. This interim program is designed to provide time and economic benefit to an operator to upgrade its simulators while enhancing safety through additional training requirements. Through the use of industry simulators, further training in adverse conditions experienced in line operations will be possible. When Phase II simulator requirements are met, the additional training requirements, except the 4 hours of LOFT training listed herein, will be removed. Part 121 training and operating experience requirements will still apply.

Each Part 121 operator who submits an acceptable simulator upgrade plan to the Administrator prior to (a date to be specified which will be 1 year after the effective date of the amendment proposed herein) may apply for approval to use a Phase I simulator for transition and upgrade training as described in Phase II of the plan. When the simulator and visual systems are upgraded to meet the requirements for Phase II or III, the additional training requirements listed in Phase II A of the plan will be removed. When applicable, the appropriate certificate or rating will be issued after the successful completion of the simulator check. The certificates issued during interim Phase II A will contain a limitation which will, in effect, restrict the applicant from acting as a flight crewmember without accomplishing the appropriate landings and hours of line operating experience in the crew position under the supervision of a specially trained check airman. To conduct Phase II A training in a Phase I simulator, all required simulator instruction and checks must be conducted in a simulator as part of a revised training program approved for the operator. This training program will include the additional training requirements of Phase II A and will integrate Phase I simulators with other simulators and training devices to maximize the total training, checking, and certification functions.

Phase II A interim ends *for each Phase I simulator* listed in the operator's approved plan 3½ years after it is approved for Phase II A training. Any simulator not upgraded according to the operator's approved simulator upgrade plan will void the plan resulting in loss of all Phase II A training. Grandfather rights will not be considered. In order for a carrier's upgrade plan to be acceptable, it must:—

1. Be submitted to the FAA prior to (1 year after the amendment proposed herein becomes effective).

2. Show which simulators will be upgraded to Phase I requirements and their projected upgrade dates;

3. Show that these simulators will meet Phase I requirements prior to 2½ years after the amendment proposed herein becomes effective);

4. Show that at least 50 percent of the operator's simulators for a particular aircraft type will be upgraded to, or be replaced with, simulators which meet Phase II or III requirements;

a. Show which simulators will be upgraded to, or replaced with, simulators which meet Phase II or III requirements;

b. Show that each of these simulators will meet Phase II or III requirements prior to 3½ years of the date it is approved for Phase I; and

5. Include a plan which shows how the instructors, check airmen, and flight crewmembers will be trained to meet the requirements of Appendix H.

Phase III—Advanced Simulation

Phase III is designed to permit all but static aircraft and operational line training and checking to be conducted in an advanced aircraft simulator. At the completion of the final simulator check, the applicant will receive the appropriate certificate or rating. Due to the scope of the training and the possible low experience level of the training candidates, a high degree of simulator fidelity and realism is mandatory. (Applicants must still meet the requirements for an airline transport pilot certificate, including 1500 hours of pilot flight time, to be eligible for that certificate under this plan.) This phase is also designed to guide research in simulator technology to meet training needs determined from aircraft accident investigations. The visual requirements of Phases II and III must therefore be represented in daylight, dusk, and night scenes under Phase III.

In summary, the increasing size, complexity, and operating costs of the modern turbojet transport and its operating environment point to greater use of the advanced technology now available in aircraft simulators. However, Federal Aviation Regulations (FAR) which currently apply to training, checking, and certification of flight crewmembers restrict the advanced use of simulation. Amending the FAR to permit nearly total simulation in advanced training simulators will encourage operators to upgrade their simulators. This will result in improved safety due to the greater training capabilities of advanced simulators. With higher percentages of training being accomplished in simulators, aircraft training flights could be reduced. This would result in a reduction in the possibility of aircraft training accidents, a reduction in airport congestion and noise, and significant fuel conservation.

The Proposed Amendment

Accordingly, the Federal Aviation Administration proposes to amend Parts 61 and 121 of the Federal Aviation Regulations (14 CFR Parts 61 and 121) as follows:

1. By adding to § 61.157 a paragraph (e) which reads as follows:

§ 61.157 Airplane rating: Aeronautical skill.

* * * * * *

(e) An airplane simulator may be used in lieu of the airplane to satsify the in-flight requirements of Appendix A of this Part, if the simulator—

(1) Is approved according to § 121.407 of this chapter and meets the appropriate simulator requirements of Appendix H to Part 121; and

(2) Is used as part of an approved program that meets the training requirements of § 121.424 (a) and (c) and Appendix H to Part 121.

2. By adding to § 121.407 a paragraph (c) which read as follows:

§ 121.407 Training program: Approval of airplanes simulators and other training devices.

* * * * *

(c) An airplane simulator may be used in lieu of the airplane to satisfy the in-flight requirements of §§ 121.439 and 121.441 and Appendices E and F of this Part, if the simulator—

(1) Is approved according to this section and meets the appropriate simulator requirements of Appendix H of this Part; and

(2) Is used as part of an approved program that meets the training requirements of § 121.424 (a) and (c) and Appendix H of this Part.

3. By adding a new Appendix H to Part 121 which reads as follows:

Appendix H—Advanced Simulation Plan

This Appendix provides guidelines and a means for achieving flightcrew training in advanced aircraft simulators. This plan for achieving the goal of advanced simulation consists of three major phases and an interim phase to facilitate the plan's implementation. The three-phase plan is to provide guidance through a progressive upgrade of flightcrew training simulators so that the total scope of flightcrew training can be enhanced. Each phase builds on the preceding phase so that the final advanced simulation phase would include all the requirements of preceding phases. This Appendix describes the simulator and visual system requirements which must be achieved in order to obtain approval of certain types of training in the simulator. The requirements set forth in this Appendix are in addition to the simulator approval requirements set forth in § 121.407. Each simulator which is used under this Appendix must be approved as a Phase I, II, or III simulator, as appropriate. In order to obtain FAA approval of the simulator for a specific phase, the following must be demonstrated to the satisfaction of the Administrator:

1. Documented proof of compliance with the appropriate simulators, visual system, and additional training requirements of this Appendix for the Phase for which approval is requested and preceding phases.

2. An evaluation of the simulator to ensure that its ground, flight, and landing performance matches the type of aircraft simulated (Phase I Approval Tests).

3. An evaluation of the appropriate simulator and visual system requirements of the phase for which approval is requested and preceding phases.

While the FAA acknowledges the need for some flexibility in making changes in the software programing, strict scrutiny of these changes is essential to ensure that the simulator retains its ability to precisely duplicate the aircraft's flight and ground characteristics. Therefore, the following procedure must be followed to permit these changes without affecting the approval of an Appendix H simulator:

1. Twenty-one calendar days prior to making changes to the software programing of an Appendix H simulator, a complete list of planned changes that impact flight or ground dynamics, including dynamics related to the motion and visual systems, must be provided to the FAA office responsible for conducting the recurrent evaluation of that simulator.

2. If the FAA does not object to the planned change within 21 calendar days, the operator may make the change.

3. Changes which might affect the approved simulator Phase I test guide must be tested by the operator in the simulator to determine the impact of the change.

4. Software changes actually installed must be summarized and provided to the FAA. Where the operator's test has shown a difference in simulator performance due to a change, an amended copy of the test guide page which includes the new simulator test results will also be provided to update the FAA's copy of the test guide.

5. The FAA retains the option to examine supporting data and/or flight check the simulator to ensure that the aerodynamic quality of the simulator has not been degraded by any change in software programing.

6. All requests for changes will be evaluated on the basis of the same criteria used in the initial approval of the simulator for Phase I, II, or III.

Because of the strict tolerances and other approval requirements of Appendix H simulators, the FAA also acknowledges that the simulator can provide realistic training with certain nonessential items inoperative. Therefore, an operator is permitted to operate its simulator under the same conditions and limitations outlined in the simulated aircraft's minimum equipment list (MEL) as long as the inoperative equipment is required within 24 hours and the inoperative equipment permitted by the MEL is not specifically required for the training involved. A simulator visual system may be inoperative at one pilot position if a pilot is not receiving training in that position, but shall be operative at both pilot positions for Line Oriented Flight Training (LOFT).

The Advanced Simulation Plan applies only to an operator who uses the simulator under an approved Part 121 training program or its equivalent. The interim phase applies only to Part 121 operators. In order to conduct total initial, transition, upgrade, or recurrent training in a simulator, all required simulator instruction and checks must be conducted in a simulator as part of a revised training program approved for the operator. This training program will integrate Phase II and III simulators with other simulators and training devices to maximize the total training, checking, and certification functions.

Phase I—Landing Maneuver Approval

Training and Checking Permitted.—1. Recency of experience (§ 121.439).

2. Night takeoffs and landings (Part 121, Appendix E).

3. Landings in a proficiency check without the landing on the line requirements (§ 121.441).

Simulator Requirements.—1. Aerodynamic programing to include:

a. Ground effect—e.g., roundout, flare, and touchdown. This would require data on lift, drag, and pitching moment in ground effect.

b. Ground reaction—Reaction of the aircraft upon contact with the runway during landing to include strut deflections, tire friction, and side forces.

c. Ground handling characteristics—steering inputs to include crosswind, braking, thrust reversing, deceleration, and turning radius.

2. Minimum of 3-axis freedom of motion systems.

3. Phase I landing maneuver test guide to verify simulator data with actual aircraft flight test data, and provide simulator performance tests for Phase I initial approval.

4. Multichannel recorders capable of recording Phase I performence tests.

Visual Requirements.—1. Visual system compatibility with new aerodynamic programing.

2. Visual system response time from pilot control input to visual system output shall not exceed 300 milliseconds. Visual system time is defined as the completion of the visual display scan of the first video field containing different information resulting from an abrupt control input.

3. A means of recording the visual response time.

4. Visual cues to assess sink rate and depth perception during landings.

5. Visual scene/instrument correlation to preclude perceptible lags.

Phase II—Simulator Upgrade Program

Training and Checking Permitted.—1. Transition training between aircraft in the same group and the certification check required by § 61.157 for pilot in command.

2. U grade to pilot-in-command training.

a. When the Pilot—

(i) Is previously qualified as second in command in the equipment to which the pilot is upgrading;

(ii) Has at least 500 hours of actual flight time while serving as second in command for the operator in an aircraft in the same group; and

(iii) Is currently serving as second in command with that operator in an aircraft in this same group; or

b. When the pilot is employed by an aircraft operator and—

(i) Is currently serving as second in command with that operator in an aircraft of the same group;

(ii) has a minimum of 5,000 flight hours as second in command in an aircraft of the same group with that operator; and

(iii) has served as second in command on at least two aircraft of the same group with that operator.

In this case, the pilot may upgrade to another aircraft in that group in which that pilot has not been previously qualified.

Simulator Requirements.—1. Representative crosswind and three-dimensional windshear dynamics based on aircraft related data.

2. Representative stopping and directional control forces for normal conditions and for contaminated runways based on aircraft related data.

3. Representative brake and tire failure dynamics, including antiskid, and the decreased brake efficiency due to high brake temperatures based on aircraft related data.

4. Six-axis freedom of motion.

5. Operational principal navigation systems, including electronic flight instrument systems, INS, and OMEGA, if applicable.

6. Means for quickly and effectively testing simulator programing and hardware.

7. Expanded simulator computere capacity, accuracy, resolution, and dynamic response to meet Phase II and III demands. Resolution equivalent to at least 32 bits for critical aerodynamic programs is required.

8. Timely permanent update of simulator hardware and programing subsequent to aircraft modification.

9. Sound of precipitation and significant aircraft noises.

10. Relative responses of the motion system, visual system, and cockpit instruments shall be coupled closed to provide integrated sensory cues. These systems shall respond to abrupt pitch, roll, and yaw inputs at the pilot's position within 150 milliseconds when the simulator is tested in a light weight, clean configuration, at maximum cruise airspeed. Visual scene changes from steady state disturbance shall not occur before the resultant motion onset but within the total system dynamic response time of 150 milliseconds. The test to determine compliance with this requirement shall include simultaneously recording the analogue output from the pilot's stick and rudders, the output from an accelerometer attached to the motion system, the output signal to the visual system display, and the output signal to the pilot's attitude indicator.

Visual Requirements. 1. Dusk and night visual scenes with specific airport representations including at least 10 levels of occulting, general terrain characteristics and significant landmarks.

2. Radio navigation aids properly oriented to the airport runway layout.

3. Built-in test protocdure to confirm visual system color, R/B, focus, intensity, level horizon, and attitude as compared to the simulator attitude indicator.

4. Weather representations including variable cloud density, partial obscuration of ground scenes, gradual breakout, patchy fog, and the effect of fog on airport lighting.

5. Category II and III weather representations.

6. Continuous minimum visual field of view of 75° horizontal and 30° vertical per pilot seat. Visual gaps shall occur only as they would in the aircraft simulated or as required by visual system hardware. Both pilot seat visual systems shall be operative simultaneously.

7. Capability to present ground and air hazards such as another aircraft crossing the active runway or converging airborne traffic.

Additional Training Requirements. A 4-hour line oriented flight training course approved in the simulator by the Administrator.

Phase II A—Interim Simulator Upgrade Program for Part 121 Operators

Under Phase II A, any Part 121 operator may conduct Phase II training for 3½ years in a simulator approved for landing maneuver under Phase I provided the operator meets the additional requirements set forth below and submits a plan acceptable to the Administrator to upgrade its simulator(s) to meet Phase II standards. In order for a carrier's upgrade plan to be acceptable, it must—

1. Be submitted to the FAA prior to (1 year after the amendment proposed herein becomes effective).

Show which simulators will be upgraded to Phase I requirements and their projected upgrade dates;

3. Show that these simulators will meet Phase I requirements prior to (2½ years after the amendment proposed herein becomes effective);

4. Show that at least 50 percent of the operator's simulators for particular aircraft type will be upgraded to, or be replaced with, simulators which meet Phase II or III requirements;

a. Show which simulators will be upgraded to, or replaced with, simulators which meet Phase II or III requirements;

b. Show that each of these simulators will meet Phase II or III requirements prior to 3½ years of the date it is approved for Phase I; and

5. Include a plan which shows how the instructors, check airmen, and flight crewmembers will be trained to meet the requirements of Appendix H.

When Phase II simulator requirements are met, the additional training requirements listed herein, except the 4 hours of LOFT training listed herein, will be removed. Part 121 training and operating experience requirements will still apply.

To conduct Phase II A training in a Phase I simulator, all required simulator instruction and checks must be conducted in a simulator as part of a revised training program approved for the operator. This training program must include the additional training requirements of Phase II A and integrate Phase I simulators with other simulators and training devices to maximize the training, checking, and certification functions.

Phase II A interim approval ends for each Phase I simulator listed in the operator's approved plan 3½ years after that simulator is approved for Phase II A training. Any simulator not upgrading according to the operator's approved simulator upgrade plan will void the plan resulting in the loss of all Phase II A training for that operator. Grandfather rights will not be considered.

Training Permitted: Same as Phase II.

Simulator Requirements: Same as Phase I.

Visual Requirements: Same as Phase I.

Additional Training Requirements:

1. In addition to the simulator training and the simulator certification and proficiency check, and prior to the line operating experience training, participating flight crewmembers must complete a 4-hour Line Oriented Flight Training Program in the simulator to prepare them to perform line duties.

2. Each participating pilot in command must be given 5 landings and 25 hours, and each second-in-command must be given 3 landings and 15 hours of line experience at his/her crew station under the supervision of a specially trained check airman.

3. Participating check airmen must be given a 4-hour training course to familiarize them with the Phase II A program and to emphasize their role in the program. They shall also be qualified to provide both line and proficiency checks or be a line check airmen who has successfully completed an approved simulator check airman course.

Phase III—Advanced Simulation

Training and Checking Permitted.—Initial, transition, upgrade, and proficiency training required under Appendix A to Part 61 and §§ 121.424 and 121.441 of Part 121. The static airplane requirements of Appendix E to Part 121 and the operating experience requirements of § 121.434 are still required to be performed in the airplane.

Simulator Requirements.—1. Simulator data on the specifics of motion bumps, including frequency and amplitude.

2. Aircraft related data for programing motion bumps to represent turbulence and other aircraft buffets. These data should include the vertical and lateral load factors of aircraft buffets.

3. Aerodynamic modeling for aircraft type certificated after January 1, 1980, including ground effect, mach effect at high altitude, effects of airframe icing, normal and reverse dynamic thrust effect on control surfaces, aero-elastic representations, and representations of nonlinearities due to side slip.

4. Realistic amplitude and frequency of cockpit noises/sounds, including thunder, precipitation static, engine and airframe sounds. The sounds shall be coordinated with the weather representations required in item 3 below.

5. Self-testing for simulator hardware and programing.

6. Diagnostic analysis printout of simulator malfunctions.

Visual Requirements.—1. Daylight, dusk, and night visual scenes with sufficient scene content to recognize a specific airport, the terrain, and major landmarks around that airport. The daylight visual scene must be part of a total daylight cockpit environment. For the purpose of this rule, daylight visual

system is defined as a visual system capable of producing, as a minimum, full color presentations, scene content of 4000 edges or 1000 surfaces for daylight and 4000 light points for night and dusk scenes, 6 foot lamberts of light at the pilot's eye, 3 arc minutes resolution at the pilot's eye, and a display which is free of quantization and other distracting visual effects while the simulator is in motion.

2. Landing illusions including short runway, landing over water, runway gradient, visual topographic features and rising terrain.

3. Special weather representations which include the sound, visual, and motion effects of entering light through heavy precipitation near a thunderstorm.

4. Phase II visual requirements in daylight as well as dusk and night representations.

5. Wet and, if appropriate for the operator, snow-covered runway representations, including runway lighting effects.

6. Realistic color and directionality of airport lighting.

7. Weather radar presentations in aircraft where radar information is presented on the pilot's navigation instruments.

Additional Training Requirements.—A 4-hour Line Oriented Flight Training course approved by the Administrator.

(Secs. 313, 601, 603, and 604, Federal Aviation Act of 1958, as amended (49 U.S.C. 1354, 1421, 1423, and 1424); sec. 6(c), Department of Transportation Act (49 U.S.C. 1655(c)).)

Note.—The FAA has determined that this document involves a regulation which is not significant under Executive Order 12044, as implemented by DOT Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A copy of the draft evaluation prepared for this action is contained in the regulatory docket. A copy of it may be obtained by contacting the person identified under the caption "FOR FURTHER INFORMATION CONTACT."

Issued in Washington, D.C., on November 6, 1979.

Kenneth S. Hunt,

Director of Flight Operations.

[FR Doc. 79-34838 Filed 11-9-79; 8:45 am]

BILLING CODE 4910-13-M

gym copy 80555 cc for Wiebe Milhoan #5 JG

File 6008 also set up File for Simulators and include this

NUCLEAR POWER PLANT SIMULATORS FOR USE IN OPERATOR TRAINING

This has a long way to go!
GEW 11/13/79

1. SCOPE

This standard establishes the minimum requirements for nuclear power plant simulators for use in operator training and requalification programs. Simulators of test, mobile and research reactors, as well as reactors not subject to the U.S. Nuclear Regulatory Commission (NRC) licensing, and limited scope simulators intended for specialized training or familiarization are excluded. Minimum criteria are set for degree of simulation, performance and functional capability of the control room instrumentation and controls, but criteria for use of such simulators is not addressed in this standard.

Good faith omitted

1.1 Background Data

Operating and training practices differ among the various organizations which operate nuclear power reactors; however, common goals are assurance of safety, equipment availability, and efficient operations. It is intended that this standard provide flexibility in design and use of a nuclear power plant simulator.

Add

It is intended that in meeting the criteria of this standard, the simulator will possess a sufficient degree of completeness and accuracy to meet the needs of industry and the requirements of NRC as described in Title 10, Code of Federal Regulations, Part 55, "Operators' Licenses," American National Standard for Selection and Training of Nuclear Power Plant Personnel, ANSI/ANS-3.1-1978, and American National Standard Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants, N18.7-1976/ANS-3.2.(1,2,3)[1]

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1 Numbers in brackets refer to corresponding numbers in Section 6, References.

2. DEFINITIONS

For the purpose of this standard, the following words and phrases are defined:

backtrack. Restoration of the simulator to a previous set of conditions which have been automatically recorded at designated time intervals.

critical parameters.
(1) Those parameters that require direct and continuous observation to operate the power plant under manual control.
(2) Input parameters to plant safety systems.

freeze. A condition whereby the dynamic simulation will be interrupted and remain static until the simulator is taken out of the "freeze" mode, at which time dynamic simulation resumes.

initialization condition. The preprogrammed condition prior to the start of the operation of the simulator.

malfunction. Failure or degradation in performance of plant equipment.

operator training. That training given to prospective and licensed (requalification) nuclear power plant reactor operators and senior reactor operators to meet the requirements of 10CFR55, ANSI/ANS-3.1-1978, and N18.7-1976/ANS-3.2. [1,2,3]

real time. Simulation of dynamic performance in the same time base relationships, sequences, durations, rates and accelerations as the dynamic performance of the reference plant.

reference plant. The specific nuclear power plant from which the simulator control room configuration, system control arrangement and simulator data base is derived.

shall, should and may. The word "shall" is used to denote a requirement; the word

looks like these were taken from a published std.? Which one?

"should" to denote a recommendation; and the word "may" to denote permission, neither a requirement nor a recommendation.

simulator data base. The "simulator data base" may be predicted data, plant design data, or it may include actual reference power plant performance data.

snapshot. The instantaneous storage of existing conditions at any selected point in time. The stored condition then becomes a temporary initialization point and may be called up repeatedly.

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3. GENERAL REQUIREMENTS

The nuclear power plant simulator is intended to be used primarily as a training device to provide initial and requalification training for nuclear power plant operators. It shall provide complete and accurate simulation of control room equipment, plant systems, and plant operation as described in the following paragraphs. The extent of simulation shall allow the operator to fully participate in appropriate plant evolutions and permit control of unusual transients to a conclusion.

3.1 Simulator Capabilities

3.1.1 Normal Plant Evolutions

The simulator shall be capable of simulating continuously, and in real time, plant operations of the reference nuclear power plant. The response of the simulator resulting from operator action, automatic plant controls and inherent operating characteristics shall be realistic to the extent that the operator shall not observe a difference, within the limits of the performance criteria, between the control room indications of the simulator and the reference plant. The simulator shall calculate plant system parameters corresponding to particular operating conditions, display these parameters on the appropriate instrumentation, and provide proper alarm or protective system action, or both. The minimum evolutions that shall be performed on the simulator, using only operator action normal to the reference plant, are defined in the following list.

1. Plant startup - cold (refueling conditions of temperature and pressure) to hot standby.
2. Nuclear startup, hot standby to 100% full power.
3. Turbine startup and generator synchronization.

4 Power escalation to 100% power.

5 Reactor trip followed by recovery to 100% power.

6 Operations at hot standby.

7 Power system load changes (manual and automatic control).

8 Power operations with less than full reactor coolant flow.

9 Plant shutdown and cooldown to cold (refueling) conditions.

10 Core physics testing after load or reload.

11 Operator conducted surveillance test on safety-related equipment or systems.

Add:

3.1.2 Plant Malfunctions

The simulator shall be capable of simulating in real time a minimum of seventy-five (75) abnormal and emergency conditions resulting from malfunctions to demonstrate inherent plant response and functioning of automatic plant controls. Each of the generic accidents analyzed in the reference plant safety analysis report which results in observable indications on control room instrumentation shall be provided, and each shall be considered a single malfunction. The remainder of the minimum number shall consist of a variety of malfunctions associated with the electrical, auxiliary, engineered safety systems and steam systems. Where applicable to the malfunction, the simulator shall provide the capability for the operator to take action to recover the plant or mitigate the consequences, or both. Plant response to the malfunctions shall be carried out to a reasonable operating condition, as determined by an analysis of the training value of each malfunction. The abnormal and emergency conditions listed below shall be included, as applicable to the type of reactor.

(1) Loss of coolant

add various sizes "leaks"

(a) including significant PWR steam generator leaks

(b) inside and outside primary containment

(c) large and small reactor coolant breaks including demonstration of saturation and subcooled condition also superheat for BWR

(2) Loss of instrument air.

Expand

(3) Loss of electrical power (and/or degraded power sources).

1 loss of offsite AC
2. " " onsite AC
3. " " all AC
4. " " onsite DC
5. " " all power

(4) Loss of forced core coolant flow. (plus establishment of natural circulation)

(5) Loss of condenser vacuum.

(6) Loss of service water or cooling individual component.

(7) Loss of shutdown cooling.

(8) Loss of component cooling system or cooling to individual components.

(9) Loss of normal feedwater or normal feedwater system failure.

(10) Loss of all feedwater (normal and emergency). also each individually

add loss of each safety system e.g. ECCS, containment isolation etc

(11) Loss of protective or system channel.

(12) Mispositioned control rod or rods and rod drops.

(13) Inability to drive control rods. (out but not in, vice versa) (only fast etc.)

(14) Fuel cladding failure or high activity in reactor coolant or offgas.

See suggestions in Section 3.1.1

(15) Turbine trip.

(16) Generator Trip.

(17) Malfunctions in automatic control system(s) which affect reactivity or and core heat removal.

(18) Malfunctions of reactor coolant pressure/volume control system.

Change to correspond to 3.1

(19) Reactor trip.

(20) Main steam line break (inside or outside containment).

(21) Nuclear instrumentation failure(s).

3.2 Control Room Environment

3.2.1 Control Panels

The control panel physical arrangement, size, and front panel mounted components shall closely parallel the reference plant. Plant information shall be displayed to the operator in the same form that it is available in the reference plant; i.e., meters, recorders, etc. Controls, meters, alarms, recorders, switches, annunciators, controllers and other components that would function during normal and abnormal operations as defined in 3.1.1 and 3.1.2 shall be furnished in the simulator. These panels shall be functional to the extent that control manipulations performed during normal and abnormal evolutions are operable.

not enforceable - why not identical?

- meaning not clear!

3.2.2 Control Room Environment

not enforceable!

Consideration shall be given to simulating as much of the control room environment as is reasonable and practical, for example, turbine noise, control rod step counter noise, flooring and lighting. Communication systems that a control room operator would use to communicate with an auxiliary operator or other support activities shall be operational to the extent that the simulator instructor, when performing these remote activities, shall be able to receive the communication over the appropriate communication system.

why not 2-way comm?

why not list of systems to minimum

3.3 Systems to be Simulated and the Degree of Completeness

3.3.1 Systems Controlled from the Main Control Boards

The inclusion of systems of the reference plant and the degree of simulation shall be to the extent necessary to perform the reference plant evolutions described in 3.1.1 and the malfunctions described in 3.1.2. It shall be possible to perform these control manipulations (using same controls required in the real plant) and observe plant response (on the same indicators/recorders/lights/annunciators) as in the reference plant.

3.3.2 Systems Operated or Functions Controlled Outside of the Control Room

The systems that are remotely operated or that provide some input to the main simulation model and are necessary to perform reference plant evolutions described in 3.1.1 and malfunctions described in 3.1.2 shall be simulated. (meaning?) It shall be possible to interface with the remote activity (meaning? communication?) in the same manner as in the reference plant.

3.4 Simulator Training Capabilities

The simulator shall contain:

why not all 20- why specify any particular number

3.4.1 Initial Conditions:

The simulator shall possess a minimum capability of 20 initialization points. At the time of commencement of operations of the simulator in the training program, a minimum of 10 initialization points shall be operational and shall include a variety of plant operating conditions (specify) and fission product poison concentrations (specify range). Various times in core life shall be included in making use of the additional (add'l to what?) initialization capability.

not enforceable

3.4.2 Malfunctions

how? where?

It shall be possible to conveniently insert and terminate the plant malfunctions specified in 3.1.2. The simulator shall be capable of simulating simultaneous malfunctions, if these malfunctions can be expected to occur simultaneously either by design or operational experience. The introduction of a malfunction shall not alert the operator to the impending malfunction.

these will need to be specified

need to specify what makes this possible

3.4.3 Other Control Features

e.g. silent instructor switches
wireless instructor controls

The simulator shall have the capability of freezing simulation. In addition, consideration should be given to incorporation of fast time, slow time, backtrack, and snapshot capabilities.

details on these would be helpful.

3.4.4 Instructor Interface

The capability shall be provided for the instructor to act in the capacity of auxiliary or other operators remote from the control room, for example, change the operating condition of valves, breakers or other devices.

we should get a few (1) simulator purchase specs
(2) " proposals
to get a better idea of how these functions have been specified by simulator buyers + sellers.

This sadly lacking in specifying the instructor interface hardware and its rigid capabilities!

4. Performance Criteria

A nuclear power plant simulator shall present to an operator, in training, quantitative values of plant parameters within the tolerance specified for those conditions that the simulator is designed to simulate.

4.1 Steady State Operation

The simulator accuracies will be related to full power values. In conducting test, the error shall be determined at several points over the power range.

(1) The simulator instrument error shall be no greater than that of the comparable meter, transducer and related instrument system of the reference plant.

(2) The simulator computed values for the mass and energy balance shall be consistent with ± 2%. The parameters displayed on the control panels that represent the mass and energy balance may have the instrument error indicated in 4.1(1) added to the computed values. Examples of principal mass and energy balance are:

Reactor power indication to generated electrical power.

Primary system temperature to steam generator pressure.

Feedwater flow to reactor power.

Mass balance of pressurizer.

Mass balance of steam generator.

(3) The simulator computed values of critical parameters shall agree with the reference plant parameters by ± 2%. Examples of the critical parameters are:

Reactor power.

Reactor hot and cold leg temperatures.

Feedwater flow.

Steam pressure.

Generated electrical power.

Recirculation flow.

Primary system pressure.

(4) The simulator computed values for steady state, full power, automatic control operation shall not change (drift) by more than ± 2% over a 60-minute period. — basis?

(5) The calculated value of noncritical parameters pertinent to plant operation, that are included on the simulator display panels, should agree with the reference plant within ±10% and should not detract from training. (What are these?)

4.2 Transient Operation

Tests shall be conducted to prove the capability of the simulator to perform those evolutions identified in 3.1.1 and 3.1.2 of this standard. Acceptance criteria for these tests shall:

Where applicable, be within limits of plant startup test procedure acceptance criteria.

Not violate the physical laws of nature. good!

Require that the observable change in the parameters correspond in direction and magnitude (accuracy and time response?) to those expected during the simulated transient in the simulated time period.

In no case during a transient, fail to cause an alarm or trip if the reference plant would have caused an alarm or trip. Conversely, the simulator shall not cause an alarm or trip if the reference plant would not cause an alarm or trip.

Malfunctions and transients not tested by the above shall be compared to design calculations or other available information and follow the above acceptance criteria.

4.2 continued
what have previous procurements called for in the way of acceptance tests?

5. SIMULATOR UPDATE

The simulator shall be maintained within the guidelines of this standard. This shall include all systems, instrumentation, and controls as they affect the simulation model and control boards and are related to the simulator's training value. If a simulator is built before the reference plant is operational, the only information available may be the simulator data base. The initial update of the simulator shall be performed within 18 months of commencement of the reference plant commercial operation or simulator training availability, whichever is latest. This updated shall include, but not be limited to, parameters as they affect training value:

(1) Critical parameters as they affect steady state and transient response verification.

(2) Control Room Hardware.

(3) Systems Engineering.

The simulator response, as compared to the reference plant operational performance data and transients experienced by similar plants, shall then be in accordance with the criteria stated in Section 4, "Performance Criteria".

Simulator performance shall be established by the preparation of a simulator acceptance test, conduct a test of the simulator, and comparison of the simulator's performance with the reference plant test data and similar plant transients. The performance test and report shall be conducted on each of the following occasions:

(1) Initial construction and acceptance for training.

(2) Initial update.

(3) Major plant modification that affects steady state or transient response of the reference plant.

(4) Each four (4) years.

The general format and content of the simulator performance test is provided in Appendix A.

6. REFERENCES

[1] Title 10, Code of Federal Regulations, Part 55, "Operators' Licenses." Government Printing Office. Washington, DC.

[2] American National Standard for Selection and Training of Personnel for Nuclear Power Plants, ANSI/ANS-3.1-1978. American Nuclear Society, La Grange Park, IL.

[3] American National Standard Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants, N18.7-1976/ANS-3.2. American Nuclear Society, La Grange Park, IL.

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