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

APR 13 1979

MEMORANDUM FOR: Saul Levine, Director
Office of Nuclear Regulatory Research

FROM: Thomas E. Murley, Director
Division of Reactor Safety Research

SUBJECT: CHANGES IN THE SAFETY RESEARCH PROGRAM AS A RESULT OF THE THREE MILE ISLAND PLANT ACCIDENT

The accident at the Three Mile Island Plant has focused attention on ways to improve reactor safety and on areas where more research data are needed. The RSR staff is examining areas where our ongoing safety research programs should be reoriented or augmented, and they are also examining areas where new safety research programs need to be started. A list of our preliminary thoughts on an augmented research program is enclosed for your information. I should caution that I have not had time to review this list for duplication or to check the cost estimates. Nevertheless, it is clear that an augmented research program to address the safety questions raised by the Three Mile Island accident will require a Supplemental Budget Request in the range of $20-30 million for FY 1980 and an even larger increase in our planned budget for FY 1981 and subsequent years.

However, before we start down the tedious path of preparing detailed budget estimates, seeking NRR endorsement for each project, laboring through a review by the Budget Review Group and finally seeking approval by the Commission, I believe we should first go to the Commission and seek some policy guidance on what changes, if any, should be made in the safety research program in light of the accident at Three Mile Island. The reason I am recommending this step is that I do not believe we have ever been given adequate policy guidance from the Commission on the role of the research program in NRC. The Commission's involvement in the safety research program has generally been limited to reacting to staff proposals for individual research projects presented for their approval during the annual budget reviews.

During the past year or two, I have sensed that the Commission's attitude toward the research program has ranged from indifference to hostility. This perceived attitude toward the research program on the part of the Commission has been responsible, I believe, for the dramatic increase in internal reviews, investigations, audits, user office endorsements and other requirements that are seriously hindering

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the staff's ability to manage the safety research programs and is preventing us from starting new safety research programs that we believe are needed.

The most notable manifestation of the Commission's attitude toward the research program is the fact that in the past four years the Commission has cut the water reactor safety research budget requested by the Office of Research by a total of $63.9 million. For this year, FY 1979, the Commission reduced our water reactor safety research budget request by $16.4 million, the OMB reduced it by $4.4 million, and the Congress cut the budget by yet another $4.4 million. These budget reductions have clearly had an impact on our ability to develop the safety research information we feel is needed.

In light of this experience, I believe we should have an early meeting with the Commission to discuss the role of the research program in NRC and where it should be heading in the future. In the meantime, my staff and I will continue to develop plans for additional research programs we believe are needed to address the safety questions raised by the Three Mile Island accident and other safety issues such as the adequacy of seismic designs of nuclear plants.

T E Murley

Thomas E. Murley, Director
Division of Reactor Safety Research

Enclosure: Preliminary List
of Research Programs

cc w/o encl.:
V. Gossick
K. Cornell
L. Barry

cc w/encl.:
R. Budnitz
RSR Staff

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APR 13 1979

ACTIONS RELATING TO THREE MILE ISLAND

Division of Reactor Safety Research

| OFFICE | CONTACT PERSON | DESCRIPTIVE TITLE | EST. COMPLETION DATE |
|---|---|---|---|
| RES | Murley, RSR | Hydrogen uptake and dissolution in Reactor Systems Tests-Billings, Provo, Utah | 1st Report, 4/12/79<br>Ongoing |
| RES | Lanning, RSR<br>Olson, EG&G | TMI Mockup and Small Break Tests - Semiscale, INEL | Ongoing for few weeks<br>First test 4/18/79 |
| RES | Murley, RSR<br>McPherson, RSR | Studying possibility of accelerating LOFT small break tests | Plans, May 1979<br>Tests, Fall 1979 |
| RES | Tong, RSR<br>Fabic, RSR | Imputing TMI-2 characteristics into TRAC at LASL and calculate the 3/28/79 transient | Estimate in progress<br>More than a month |
| RES | Tong, RSR<br>Fabic, RSR | Inputing TMI-2 fuel parameters into COBRA and calculate fuel damage due to 3/28/79 accident | Not Available |
| RES | Fabic, RSR<br>Zuber, RSR<br>Anderson, RSR | Provide interpretation and understanding of $\Delta P$ readout in TMI-2 Control Room during a stuck relief valve incident | 4/14/79 |
| RES | Fabic, RSR<br>Zuber, RSR<br>Anderson, RSR | Provide backup review of NRR and B&W natural circulation cooling calculation | 4/13/79 |
| RES | Fabic, RSR<br>Zuber, RSR<br>Anderson, RSR | Calculate compressibity of steam/noncondensable gas mixtures | 4/20/79 |
| RES | Bennett, RSR | Determine the status of TMI core using neutron noise measurements; ORNL | ~4/20/79 |

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ACTIONS RELATING TO THREE MILE ISLAND (Cont'd)

Division of Reactor Safety Research

| OFFICE | CONTACT PERSON | DESCRIPTIVE TITLE | EST. COMPLETION DATE |
|---|---|---|---|
| RES | Stolzenberg, RSR | List of Relief Valve Testing Facilities | 4/16/79 |
| RES | Johnston, RSR<br>Ybarrondo, EG&G | Fuel and Control Rod Guide Analysis at INEL | Ongoing |
| RES | Johnston | Independant group of experts studying ability to cool TMI core using R.H.R., natural circulation or other technique | Not Available<br>Probably 4/13/79 |
| RES | Marino, RSR | Assessment of Core Damage | 4/13/79 |
| RES | Hoatson, RSR<br>Beckner, RSR | Determination of coolant water availability by location during the accident | About 4/20/79 |

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Enclosure

## Proposed Augmented Safety Research Budget

The RSR staff has prepared a preliminary list of research programs that are felt to be needed to address safety questions raised by the accident at Three Mile Island and other safety issues. The Advanced Reactor Safety Research staff were asked to include their suggestions for additional safety research, and as a result this list may include some duplication of research topics.

The staff was asked to list the research according to the following categories:

A. Firm Needs to Augment Existing Programs

B. Firm Needs to Start New Programs

C. Lower Priority or More Speculative Programs

D. New or Augmented Programs Not Related to TMI-2

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Proposed Augmented Research Budget
Division of Reactor Safety Research

A. Firm Needs to Augment Existing Programs

| | 80 | 81 | 82 | 83 |
|---|---|---|---|---|
| Separate Effects | 1500 | 1000 | - | - |
| Loss of Fluid Tests | 950 | 950 | 500 | 500 |
| Analysis Development | 1300 | 1000 | 400 | 400 |
| Fuel Behavior | 2910 | 2200 | 1200 | 1200 |
| Metallurgy & Materials | 3550 | 2250 | 1400 | 400 |
| Research Support | 1650 | 1400 | 1750 | 3550 |
| WRSR Total | 11810 | 9675 | 5825 | 4350 |
| GRSR | 1650 | 1400 | 1750 | 3550 |
| ARSR | 9300 | 14500 | 12725 | 6000 |
| RSR Total | 22760 | 25575 | 20300 | 13900 |

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Proposed Augmented Research Budget
Division of Reactor Safety Research

B. Firm Needs to Start New Programs

| | 80 | 81 | 82 | 83 |
|---|---|---|---|---|
| Separate Effects | - | - | - | - |
| Loss of Fluid Tests | 10 | 10 | - | - |
| Analysis Development | 1800 | 1600 | 1600 | 900 |
| Fuel Behavior | 3500 | 2200 | 1000 | - |
| Metallurgy & Materials | 3250 | 2800 | 1800 | 1950 |
| Research Support | 3650 | 4300 | 1350 | 680 |
| WRSR Total | 12210 | 10910 | 5750 | 3530 |
| GRSR | 1550 | 1900 | 1850 | 1450 |
| ARSR | 13900 | 22270 | 18470 | 13550 |
| RSR Total | 27660 | 35080 | 26070 | 18530 |

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Proposed Augmented Research Budget
Division of Reactor Safety Research

C. Lower Priority or More Speculative Programs

| | 80 | 81 | 82 | 83 |
|---|---|---|---|---|
| Separate Effects | 2800 | 2700 | 200 | - |
| Loss of Fluid Tests | 75 | - | - | - |
| Analysis Development | - | - | - | - |
| Fuel Behavior | 200 | 200 | - | - |
| Metallurgy & Materials | - | - | - | - |
| Research Support | - | - | - | - |
| WRSR Total | 3075 | 2900 | 200 | - |
| GRSR | - | - | - | - |
| ARSR | 1500 | 2750 | 2750 | 5600 |
| RSR Total | 4575 | 5650 | 2950 | 5600 |

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Proposed Augmented Research Budget
Division of Reactor Safety Research

D. New or Augmented Programs Not Related to TMI-2

| | 80 | 81 | 82 | 83 |
|---|---|---|---|---|
| Separate Effects | - | - | - | - |
| LOFT | - | - | - | - |
| Analysis Development | 1000 | 1000 | 500 | - |
| Fuel Behavior | - | - | - | - |
| Metallurgy & Materials | 3300 | 3900 | 4500 | 4900 |
| Research Support | 300 | 300 | - | - |
| WRSR Total | 4600 | 5200 | 5000 | 4900 |
| GRSR | 1350 | 2000 | 2850 | 2200 |
| ARSR | 2350 | 3300 | 3300 | 3000 |
| RSR Total | 8300 | 10500 | 11150 | 10100 |

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APR 12 1979

NEW CONSIDERATIONS IN WATER REACTOR RESEARCH

SEPARATE EFFECTS RESEARCH BRANCH

| | PROJECT TITLE | | FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|---|---|
| A. Firm Needs to Augment Existing Programs | | | | | | | |
| B3014 | BWR/ECC | Expand small break and reduced ECC systems availability research | - | $1,000K | - | - | 1 Year Extension |
| B6038 | Semiscale | Expand small break and reduced ECC systems availability research | ~~$1,500K~~ | — | — | — | 4 months |

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NEW CONSIDERATIONS IN WATER REACTOR RESEARCH

SEPARATE EFFECTS RESEARCH BRANCH

| | PROJECT TITLE | | FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|---|---|
| C. Lower Priority or More Speculative Programs | | | | | | | |
| A6039 | Technical Surveillance | Expand to follow BWR BD/ECC small break research | $200K | $200K | $200K | - | Through FY 82 |
| A4070 | Creare ECC Bypass | Increased technical assistance to follow Semiscale and other new programs | $100K | $100K | - | - | Through FY 81 |
| B6188 | Condensation Study | Condensation rate of steam or stratified water with non-condensable as parameter. Additional effort is needed. | $ 50K | $ 50K | - | - | 2 Years |
| B0401 | Advanced Instrumentation | Safety monitoring instrumentation; impedance probe on the wall, cheap and serviceable version that can survive in high radiation environment. Requires additional resource and efforts. | $150K | $150K | - | - | 2 Years |
| B6204 | FLECHT SEASET | Heat transfer to slow and stagnant steam. Requires work beyond the original tri-party agreement. | $100K | - | - | - | |
| A4060<br>A4055<br>B6211 | MIT<br>Lehigh<br>SUNY | Heat transfer to damaged fuel rods (porous media). Analysis of small break tests. Requires increased efforts. | $200K | $200K | - | - | 2 Years |

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NEW CONSIDERATIONS IN WATER REACTOR RESEARCH

SEPARATE EFFECTS RESEARCH BRANCH

| | | PROJECT TITLE | FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|---|---|
| C. Lower Priority or More Speculative Programs (Cont'd) | | | | | | | |
| B0125 | BDHT | Small break heat transfer experiments and analysis, expecially in-bundle tests. Rod ejection and locked motor accidents evaluation (requested by NRR). Requires improved local hydraulic and bundle | $1,000K | $1,000K | - | - | 2 Years |
| | Cooling of Rubble Beds | Forced and natural circulation through rubble beds including effect of voids, flow distribution, bed redistribution, etc. | $1,000K | $1,000K | - | - | 2 Years |

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LOFT

| | 79 | 80 | 81 | 82 | 83 |
|---|---|---|---|---|---|
| A. Needs to Augment Existing Program | | | | | |
| 1. Accelerate Small Break Schedule | 1,000 | 500 | 500 | 500 | 500 |
| 2. Natural Circulation Tests (150K Each) | | 450 | 450 | | |
| B. Needs to start New Programs | | | | | |
| 1. Reviewing Instrumentation for LPWR use | 10 | 10 | 10 | | |
| 2. Adapting Instrumentation to LPWR use | Industry Support? | | | | |
| C. Lower Priority or Speculative Programs | | | | | |
| 1. Animated Film of TMI-2 (ANL) | 75 | | | | |
| 2. Filming of Cleanup/Dismantle of TMI - 2 | | 75 | | | |
| TOTALS | $1,085 | 1,035 | 960 | 500 | 500 |

TOTAL $4,080

Note: These are rough estimates; INEL is meeting on Friday 4/13/79 and will have better estimates after that.

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ANALYSIS DEVELOPMENT BRANCH

WRSR

Supplemental Budget Needs

| PROJECT TITLE | FY 80 | FY 81 | FY 82 | FY 83 | Est. Duration |
|---|---|---|---|---|---|
| A. Firm Needs to Augment Existing Programs | | | | | |
| 1. Adaptation of TRAC to PWR transients | | | | | |
| (a) Detailed Secondary side | 100 | 100 | 0 | | 2 years |
| (b) Detailed trips & controls | 100 | 100 | 0 | | 2 years |
| (c) Noncondensible gas | 200 | 0 | 0 | | 1 year |
| (d) 1-D Kinetics | 200 | 100 | 0 | | 2 years |
| (e) Fast running, 1-D version | 200 | 200(EM) | 200 | 200 | 4 years |
| 2. Speed-up of TRAC-BWR | 200 | 200 | 200 | 200 | 4 years |
| 3. Speed-up of COBRA | 300 | 300 | 0 | 0 | 2 years |
| B. Firm Needs to Start New Programs (If new lab or new FIN no.) | | | | | |
| 1. TRAC Applications to cases of concern to NRC | 500 | 600 | 700 | 500 | 4 years |
| 2. COBRA Applications to cases of concern to NRC | 300 | 300 | 400 | 200 | 4 years |
| 3. Data Bank for LWR Systems, Components and Containments; Geometry, Operating Conditions, Trips, etc. | 500 | 500 | 500 | 200 | 4 years |
| 4. Review of codes, adaptation, possible modification for | 500 | 200 | 0 | 0 | 2 years |
| (a) Hydrogen transport within containment | | | | | |
| (b) Containment l as due to flagration, detonation | | | | | |

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| PROJECT TITLE | FY 80 | FY 81 | FY 82 | FY 83 | Est Duration |
|---|---|---|---|---|---|
| D. New or Augmented Programs Not Related to TMI-2 | | | | | |
| 1. Containments Separate Effects test: Intercompartment transient flow of air/water mixture. | 1000 | 1000 | 500 | 0 | 3 years |
| | 4100 | 3600 | 2500 | 1300 | |

290 062

FUEL BEHAVIOR RESEARCH BRANCH
(dollars in thousands)

| PROJECT TITLE | FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|
| A. Firm Needs to Augment Existing Programs | | | | | |
| 1. Continue work on fission product behavior in fuel under accident conditions. | $ 600 | $ 600 | $ 600 | $ 600 | 4 years |
| 2. Failed fuel tests in PBF. | 2000 | 1000 | | | 2 years |
| 3. Molten fuel behavior. | 310* | 600* | 600* | 600* | 4 years |
| B. Firm Needs to Start New Programs | | | | | |
| 1. Coolant chemistry after fuel failures. | 600 | (2 year contract) | | | 2 years |
| 2. Behavior of $H_2$ bubbles and $H_2/O_2$ mixtures. | 600 | (2 year contract) | | | 2 years |
| 3. Gather information on $H_2$ explosions. | 200 | | | | 1 year |
| 4. Performance requirements for failed fuel detection instrumentation. | 100 | 200 | | | 2 years |
| 5. Examination of TMI 2 fuel. | 2000 | 2000 | 1000 | | 3 years |
| C. Lower Priority or More Speculative Programs | | | | | |
| 1. Follow F.P. activity in TMI Reactor Building | 200 | 200 | | | |
| D. New or Augmented Programs Not Related to TMI-2 | | | | | |
| None | | | | | |

* Already proposed budget.

99 093

METALLURGY AND MATERIALS RESEARCH BRANCH

| PROJECT TITLE | FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|
| A. Firm Needs to Augment Existing Programs | | | | | |
| 1. Acoustic emission procedures and analyses for structural evaluation during hydrotests. | $ 250 | $ 400 | $ | $ | 2 years |
| 2. Continuous acoustic emission monitoring for automatic leak detection and location. | 200 | 300 | | | 2 years |
| 3. Automated, real time ultrasonics for detection, evaluation and display of flaws during inservice inspection. | 350 | 350 | 400 | 400 | 4 years |
| 4. Steam generator tube integrity under high temperature, pressure accident conditions. | 250 | | | | 1 year |
| 5. Integrity of primary system under LOCA/ECCS thermal shock while at high pressures. | 2500 | 1200 | 1000 | | 3 years |
| B. Firm Needs to Start New Programs | | | | | |
| 1. Postulation of areas of possible material damage based on review and evaluation of TMI-2 accident events and related environmental conditions (stress, temperature, chemical concentration, hydrogen release, radiolytic release, etc.). | 200 | 300 | | | 2 years |
| 2. Coolant composition and physical chemistry as a function of environmental conditions after fuel failures. | 750 | 800 | 850 | 900 | 4 years |

490 064

| PROJECT TITLE | FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|
| B. Firm Needs to Start New Programs (cont.) | | | | | |
| 3. Short and long-term effects of decontamination solutions and their decomposition products on corrosion, crevice corrosion and stress corrosion cracking of primary pressure boundary and auxiliary systems. | $ 500 | $ 400 | $ 400 | $ 400 | 4 years |
| 4. Analytical evaluation of integrity and consequences of explosive loading of primary system materials and components. | 300 | 200 | | | 2 years |
| 5. Test and evaluate effect of accident radiation on components. | 500 | 300 | | | 2 years |
| 6. Hydrogen embrittlement of primary system materials and components. | 500 | 300 | | | .2 years |
| 7. Short and long-term effect of accident coolant chemistry, chemical transport, dry-out and concentration on primary system integrity. | 500 | 500 | 550 | 650 | 4 years |
| C. Lower Priority or More Speculative Programs | | | | | |
| None | | | | | |
| D. New or Augmented Programs Not Related to TMI-2 | | | | | |
| 1. Stress corrosion cracking of BWR piping. | 1800 | 2100 | 2400 | 2600 | 4 years |
| 2. Stress corrosion cracking of carbon steel pressure vessel and piping materials. | 500 | 600 | 700 | 800 | 4 years |
| 3. Long-term thermal aging degradation of cast stainless steel (may not be fully public yet). | 1000 | 1200 | 1400 | 1500 | 4 years |

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RESEARCH SUPPORT BRANCH

CAPSULE SUMMARY OF PROPOSED RESEARCH PROGRAMS

| PROJECT TITLE | ESTIMATED ADDITIONAL FUNDING NEEDED (1980 DOLLARS) FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|
| A. Firm Needs to Augment Existing Programs | | | | | |
| . Qualification of Equipment Under Extended LOCA Conditions | $ 200K | $ 300K | $ 300K | $ 150K | 4 years |
| . Analysis of Instrumentation Needs During an Accident | 200K | 175K | 75K | | 3 years |
| . Safety-Related Operator Actions (including simulator studies) | 400K | 300K | 200K | 200K | 5 years |
| . Complete Environmental and Flow Discharge Testing of Valves | 500K | 1,000K | 1,000K | 500K | 5 years |
| . Requalification Requirements for Equipment After an Accident | 300K | 500K | 750K | 1,000K | 8 years |

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| PROJECT TITLE | ESTIMATED ADDITIONAL FUNDING NEEDED (1980 DOLLARS) FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|
| B. Firm Needs to Start New Programs | | | | | |
| . Upgraded Engineered Safety Features (Review and Computer Simulation) | $ 500K | $1,100K | $ 600K | $ 200K | 4 years |
| . System Interactions During Normal Operations and During and After an Accident | 400K | 400K | 300K | 300K | 5 years |
| . Computer Diagnostics of Plant Conditions (Plant Monitoring System) | 500K | 500K | 250K | 180K | 4 years |
| . Analysis of Requirements for a Dedicated, Closed Cycle Residual Heat Removal System | 400K | 300K | | | 2 years |
| . Develop Upgraded Safety Requirements for Containment Systems (Experimental work will probably be needed later) | 300K | 300K | | | 2 years |
| . Review of and Establishment of Guidelines for Safe Operation of Secondary System | 300K | 300K | | | 2 years |
| . Complete System Analysis of Entire Design, Fabrication and Operation Process | 300K | 400K | 200K | | 3 years |
| . Treatment of Hydrogen Bubbles Under Accident Conditions | 400K | 400K | | | 2 years |
| . Study of Management Organizational Structure for Accident Control | 200K | 300K | | | 2 years |

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| PROJECT TITLE | ESTIMATED ADDITIONAL FUNDING NEEDED (1980 DOLLARS) FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|
| D. New or Augmented Programs Not Related to TMI-2 | | | | | |
| . Complete Review and Analysis of Offsite and Emergency Power Requirements | $ 300K | $ 300K | | | 2 years |

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## Proposed Augmented Research Budget
## for General Reactor Safety Research

| PROJECT TITLE | ($ in thousands) FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|
| **A. Firm Needs to Augment Existing Programs** | | | | | |
| 1. Achievement of High Reliability in Operability of Safety Related Pump and Valve Systems in Nuclear Power Plants | 350 | 600 | 900 | 700 | 6 years |
| 2. Atmospheric Transport and Diffusion of Radioactive Effluents<br>a. roof vent release<br>b. river valley dispersion<br>c. meteorological measurement network requirements | 300 | 300 | 350 | 350 | 5 years |
| 3. Safety Margins for Containments (Accelerate a program to determine actual failure modes and load levels under symmetric and unsymmetric loadings, e.g., explosions) | 1000 | 500 | 500 | 2500 | 5 years |
| **B. Firm Needs to Start New Programs** | | | | | |
| 1. Damage Assessment of Nuclear Power Plant Structures, Systems and Components Subsequent to Severe Accident and Environmental Events | 750 | 700 | 700 | 700 | 4 years |
| 2. Evaluation of Failure Modes of Reactor Pressure Vessels, Other Safety Related Equipment Subjected to Internal Accident Explosions | 300 | 200 | 200 | 0 | 3 years |
| 3. Assessment of Damage Expectation of Equipment Subjected to Extended LOCA Environments and Development of Equipment Qualification Requirements | 200 | 300 | 750 | 750 | 4 years |
| 4. Seismic Shutdown (Investigate possible plant conditions subsequent to a seismic event and establish requirements to assure ability to attain cold shutdown) | 300 | 700 | 200 | 0 | 3 years |
| **C. Lower Priority or More Speculative Programs** | | | | | |
| None | | | | | |

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Proposed Augmented Research Budget

for General Reactor Safety Research

| PROJECT TITLE | ($ in thousands) FY 80 | FY 81 | FY 82 | FY 83 | EST. DURATION |
|---|---|---|---|---|---|
| D. New or Augmented Programs Not Related to TMI-2 | | | | | |
| 1. The Design of Steel Energy Absorbing Restrainers and Their Incorporation into Nuclear Power Plants for Enhanced Safety | 50 | 500 | 500 | 500 | 10 years |
| 2. Verification of Computer Codes for Design of Structures, Components, Equipment and Systems in Nuclear Power Plants | 750 | 1000 | 1800 | 1400 | 7 years |
| 3. Benchmarks for Verification of Structural Computer Programs for Design of Nuclear Piping Systems | 200 | 200 | 200 | 200 | 4 years |
| 4. Water Hammer Effects (Augment a program which considers the effects initiated by a water hammer to include the possibility of inducing a water hammer event during abnormal occurrences) | 150 | 300 | 350 | 100 | 4 years |

070 66

ARSR

Control Room Access

Control Room integrity and accessibility - bunkered back-up and functional isolation provisions. (Issue # NUREG-0138, 0153)

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 175K | 250K | 300K | 200K |

Estimated duration - 4 years

Category A

99 071

Off-Site Power Stability

Electric Grid Stability assessment methodology development and offsite power accessibility - GDC-17 (Issue #24 NUREG-0153).

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 175 | 250 | 175 |

Estimated duration - 3 years

Category A

99 072

## Environmental Qualification

Environmental Qualification of equipment (inside and out of containment) for worst case accident - diversity of components, design, and function parameter. Range selection and overlap, synergistic effects of hostile environmental components (e.g., radiation and chemicals, etc.).

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 400K | 600K | 750K | 300K |

Estimated duration - 4 years

Category A

99 073

## Common Mode Studies

A systematic, coordinated study to identify and devise remedies for common mode failures of safety systems and components including the contribution of human factors (pro and con). (Issue #8 NUREG-0138)

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 350K | 400K | 350K | 200K |

Estimated duration - 3 years

Category A

99 074

99 074

Systems Interaction Study

Plant dynamics and control and their effects on safety system performance. (Issues #6 and #22 in NUREG-0138 and 0153)

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 400K | 500K | 750K | 500K |

Estimated duration - 4 years

Category A

99 075

Core-Melt Vessel Protection Materials Experiments

Small-scale in-pile experiments upon the attack of molten $UO_2$ and other melts upon potential in-vessel (as well as ex-vessel) protective and sacrificial materials such as MgO. Extension of current LMFBR program.

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 600 | 900 | 500 |

Category A

99 076

## Particulate Debris Coolability

In-pile experiments (internal debris heating) and analysis on the coolability of particulate core debris as a function of pressure and water flow rate. Extension of current LMFBR program.

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 600 | 1,000 | 1,500 | 1,000 |

Category A

99 077

RWW

## Steam Explosion Experiments with Molten $UO_2$

Dropping-mode steam explosion experiments including ambient pressure variations using the new large melt facility (100 kg molten $UO_2$ at Sandia). Extension of LMFBR program related to LWR program.

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 600K | 1600K | 1200K |

Category A

99 078

High Reactivity Insertion (ATWS)
Work-Potential Experiments in PBF

A series of the higher ramp rate ATWS transients with fresh and irradiated fuel in PBF to measure and model the work potential and the threat to integrity of the primary system. This program follows from the poorly instremented ST-4 PBF test in which a very high pressure but moderate work potential steam explosion occured in a very high reactivity excursion from BWR standby conditions.

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 400K | 1400K | 1600K | 1200K |

Category A

99 079

Items 1 through 4 can also be combined with the title:

Integrated Radioactivity Transport Research

| | 80 | 81 | 82 |
|---|---|---|---|
| Source Term | 400 | 400 | 300 |
| Code Improvements | 300 | 200 | 100 |
| Transport Tests | 600 | 600 | 500 |
| Vented Contain System | 600 | 1,000 | 1,000 |
| TOTAL | 1,900 | 2,200 | 1,900 |

Category A

99 080

M.S.

1. Aerosol Source Terms for Radiological Transport Under Molten Core Conditions. (Rate and composition of materials released during various stages of core melt to provide input conditions for aerosol transport code analysis, includes fuel, f.p.s, clad, structure). (Extension of LMFBR program at Sandia and Mound).

| FY 80 | FY 81 | FY 82 |
|---|---|---|
| 400 | 400 | 300 |

99 081

2. Aerosol Behavior Code Improvement for Radiological Transport During Accidents. (Extend HAARM-3/CRAB aerosol codes to include LWR conditions: condensation, multiple zones and mixed species, transport property measurements, vented containment system.)

| FY 80 | FY 81 | FY 82 |
|---|---|---|
| ~~200~~ 300 | 200 | 200 |

99 082

M.S.

3. Radiological Aerosol Transport During Accidents. (Extension of mixed aerosol tests in NSPP to include LWR aerosols and containment environments for verification of improved aerosol codes.)

| FY 80 | FY 81 | FY 82 |
|---|---|---|
| 600 | 600 | 500 |

99 083

M.S

4. Vented Containment System Component Performance Requirements and Testing. (Aerosol load assessment using improved codes: determining system design requirements; candidate selection for testing; and performance tests of components) (assumes use of existing facilities - NSPP, CSE).

| FY 80 | FY 81 | FY 82 | FY 83 |
|---|---|---|---|
| 600 | 1,000 | 1,000 | * |

*Subject to assessment of need for special test facility.

99 084

PROJECT TITLE

Fission Product Mobility in Steam

This effort would be a direct extension of studies begun in connection with the HTGR safety program using the thermochromatographic technique below about 1600°C and an induction furnace for studies up to the fuel melt temperature.

COSTS

| FY 1980 | FY 1981 | FY 1982 | FY 1983 | TOTAL |
|---|---|---|---|---|
| 1000K | 2000K | 2000K | 2000K | 10,000K |

This is a category A program.

99 085

PROJECT TITLE

Containment Gas Mixing

This development and testing of analysis methods for the reliable prediction of gas mixing in the reactor containment is a direct continuation of the effort initiated under the HTGR safety program to develop the capability to predict the mixing of hot helium depressurization jets with the containment atmosphere.

COSTS

| FY 1980 | FY 1981 | FY 1982 | FY 1983 | TOTAL |
|---|---|---|---|---|
| 400K | 1000K | 1000K | 600K | 3000K |

This is a category A program.

99 086

## Plant Systems Codes

Accident analysis code (TRAC) should be expanded to model the entire plant. Key features which need to be added are the plant control and protection system and provisions for user interjection of operator actions. SSC has generalized models of plant control and protection systems which could be adapted for use.

| | |
|---|---|
| FY-80 | ~~$600K~~ 700 |
| FY-81 | ~~$700K~~ 900 |
| FY-82 | 700 |
| FY-83 | -- |

Estimated duration - ~~2~~ 3 years

99 087

Containment integrity under the spectrum of core melt accidents. (Category A)

| Analyses | FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|---|
| | 750K | 750K | 0 | 0 |

Experiment: follow-on to needs identified during analyses.

99 083

Plant Safety Margins - LOCA Sensitivity Calculations

Review LOCA analyses to determine sensitivity of remaining plant safety margins to additional loss of emergency equipment (i.e., aux. feedwater not available when called for during accident sequence). (Category A)

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 750K | 750K | 0 | 0 |

99 089

# ARSR

## Safety System Aging

Study of Aging Effects of electrical and mechanical equipment and devise measures to counter these effects.

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 250K | 500K | 500K | 500K |

Estimated duration - 4 years

Category B

99 090

System Hardening

Hardening of safety systems against the Electromagnetic Pulse (EMP). (Issue #27 NUREG-0153. Memo to the Commissioners from D. L. Basdekas dated February 15, 1979)

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 350K | 500K | 300K |

Estimated duration - 3 years

Category B

99 071

## Lighting Protection of Safety Systems

Lightning Protection of Class IE and non-Class IE Systems--establishment of threshold protection, grounding, arrestor and protective devices configuration.

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 100K | 250K | 200K |

Estimated duration - 3 years

Category B

99 092

## Post Accident Monitoring

Post-accident parameter monitoring,in-core flux detectors and temperature sensors - range selection and overlap, environmental/seismic qualification, location selection and diversity of parameter, design and components. Power source diversity.

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 200K | 250K | 350K | 250K |

Estimated duration - 4 years

Category B

99 093

Accident Progression Analysis

Analysis of steam line break and LOCA in tandem - steam generator tube integrity and its effects on accident progression.
(Issue #23 in NUREG 0153)

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 300K | 400K | 450K |

Estimated duration - 3 years

Category B

99 094

Transient Behavior of Major Components Under Flow Transient Behavior

1. Steam Generators - investigate thermal stress and load stress under dry out and reflood conditions.

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 300K | 500K | 200K |

2. Pumps - evaluate: pump life under dry out conditions, coolant surge into a dry running pump (possible?), redesign recommendations.

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 50K | 200K | 100K |

3. Valves - evaluate reclosure procedures and capabilities, recommendations for changes.

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 300K | 400K | 100K |

4. Piping - review of TMI transients and other plants to identify possible conditions not covered by current designs.

| FY-80 | FY-81 | FY-82 |
|---|---|---|
| 400K | 400K | 200K |

5. Pressure vessel - evaluate "return to service" requirements after partial melt (including ISI).

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 500K | 1000K | 800K | 600K |

| | | | | |
|---|---|---|---|---|
| TOTAL | 1550K | 2500K | 1400K | 600K |

Category B

99 095

New Instrumentation Feasibility Study

The lack of knowledge of where the primary coolant was and how much of it there was at TMI indicates the need for independent and reliable instrumentation. This instrumentation need not have the accuracy needed for normal operation if it meets the reliable and independent criteria.

It is suggested that a "weighing" system be evaluated. That is load cells to take gravitational loads or perhaps strain guages attached to support structures already in place could be utilized.

| FY-80 | FY-81 |
|---|---|
| 100K | 200K |

Category B

99 096

T.M.

## Coolability Analysis and Experiments for a Damaged Core Containing Particulate Debris

Detailed analysis using COMMIX of the coolability of a damaged LWR core that contains a region of particulate core debris with necessary supporting experiments (laboratory possibly in-pile) on the thermal-hydraulic characteristics of the particulate region.
New Program.

| FY 80 | FY 81 | FY 82 | FY 83 |
|---|---|---|---|
| 600 | 1,000 | 1,800 | 1,800 |

Category B

99 097

## Coolability Tests of Damaged Fuel Assemblies

A series of In-pile tests in PBF, or possibly ETR, and coolability of an array of damaged fuel pins over a range of accident conditions.

| FY 80 | FY 81 | FY 82 | FY 83 |
|---|---|---|---|
| 1,500 | 5,000 | 5,000 | 5,000 |

Category B

99 098

PROJECT TITLE

Emergency Control/Operation of Reactor

Develop standby or emergency methods of controlling the plant and reactor systems under emergency or accident conditions where normal controls and/or components may not be fully functional or may be jeopardized by operation under accident conditions. Phase 1 would involve study to determine which systems and components are most vulnerable. Phas 2 would involve development and testing of surrogate methods (and equipment.)

COSTS

| FY 1980 | FY 1981 | FY 1982 | FY 1983 | TOTAL |
|---|---|---|---|---|
| 500K | 1000K | 2000K | 1000K | 5000K |

CATEGORY B

99 099

PROJECT TITLE

Effects of Hydrogen Explosions on Instrumentation

Determine the effects of hydrogen explosions as they may occur inside of the primary system under accident conditions, or within the reactor containment building, on the reliability of instrumentation for the reactor plant operation and accident diagnosis.

COSTS

| FY 1980 | FY 1981 | FY 1982 | FY 1983 | TOTAL |
|---|---|---|---|---|
| 500K | 800K | 800K | 800K | 3500K |

CATEGORY B

PROJECT TITLE

Instruments Seismic Survival

The program should involve an iterative determination of:

a) the information requirements for related accident recovery,

b) the ability to develop or harden sensors to provide the information.

COSTS

| FY 1980 | FY 1981 | FY 1982 | FY 1983 | TOTAL |
|---|---|---|---|---|
| 500K | 1000K | 1000K | 1000K | 3500K |

This is a category B program.

This program should be related to any program involved with survival in radiation environments.

## Emergency $H_2$ Reduction Methods (Category B)

A. Pressurizer spray and gas bleed--Kinetics of gas evolution in pressurized systems.

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 0.2M | 0.2M | 0 | 0 |

B. $H_2$ gettering (trapping) or fixing

Candidates: $H_2O_2$, Organic getters (i.e., olefins, unsaturated organic complexes).

Parameters: Coolant temperature and pressure, radiation field strength and catalyst requirements.

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 1.0M | 2.0M | 2.0M | 2.0M |

## $H_2$ Solubility in Water (Category B)

Data on hand for single gas (i.e., $H_2$, $O_2$, $N_2$, etc.). Need data when multiple gases are present, e.g., $H_2$ + $N_2$ + Xe + other likely candidates.

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 0.2 M | 0.2 M | 0 | 0 |

## $H_2$ Generation/Recombination in Water In Radiation Fields (Category B)

A. Liquid phase parameters: $H_2$ conc., temperature, pressure radiation field strength and nature of gas overphase. Experimental facility: loop in ETR-type facility.

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 2.5M | 2.5M | 1.0M | 0 |

B. Gas phase parameters: $H_2$, $O_2$, water vapor, $N_2$, other gases present (nobles), radiation field strength, temperature and pressure.

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 2.0M | 2.0M | 0 | 0 |

Rad-Waste Tank Capacity - LOCA Requirements

Assessment of rad-waste (liquid and gas) capacity needs following current LOCA scenarios then for follow-on sensitivity scenarios (suggested above). (Category B)

| FY-80 | FY-81 | FY-82 | FY-83 |
|---|---|---|---|
| 70K | 70K | 70K | 0 |

99 105

## Plant System Simulator

Research to develop a realtime interactive plant simulator that could be used as part of the emergency action center. The simulator would follow the course of transients and accept operator actions on an ad hoc basis with the capability to follow the accident as it develops as a result of operator actions and system interactions.

| | |
|---|---|
| FY-80 | $600K |
| FY-81 | $1,000K |
| FY-82 | $1,000K |
| FY-83 | $ 0 K |

Estimated duration - 3 years

This is Category B.

## Study the Performance of Damaged Components

Conduct an in-depth review using the best available multidimensional thermal hydraulics codes (COMMIX, COBRA-4, etc.) to study flow and heat transfer in damaged components of a reactor system. The degraded performance characteristics should then be incorporated into a plant system analysis to discover interactive relationships and to explore strategies for managing a plant with one or more damaged components. In the course of the study, improvements to the codes would be identified and implemented as required.

| | |
|---|---|
| FY-80 | $800K |
| FY-81 | $900K |
| FY-82 | $600K |
| FY-83 | $600K |

This is a new (Category B) effort, but the activity is similar to existing activities in the FBR program using COMMIX and SSC; hence, the COMMIX activity could be augmented (Category A) to this broadened scope.

ARSR

NRC Interactive Emergency Action Center

A research program is needed to define a computer supported emergency action center with the capability to accept real time data from the disabled plant. The center would function much as a military command and control center with on-line processing of data relayed from the plant instrumentation through a suitable data link (satellite?). This data would be fed into a plant simulation model to allow the staff to anticipate trends and to study options for dealing with the emergency. When not reacting to emergency the computer could maintain a detailed status report on each plant. For example, when a system is down or taken off line for maintenance, the reduced configuration could be compared to technical specifications to detect violations. Maintaining the status would leave significant time for the computer to be used for the support of licensing review.

| | |
|---|---|
| FY-80 | $1M |
| FY-81 | $2M |
| FY-82 | $2M |
| FY-83 | $5M (IMPLEMENTATION) |

This is a category C item but the technical feasibility of the system is not in doubt: similar systems are in use by DOD, AT&T, most large public utilities(for load equalizing) and much of the petro-chemical industry. The main aim of research is to develop the "user needs" ,define required software and thus prepare an RFP-scheduled for FY-83.

99 108

Human Engineering Factors in Reactor Safety

From the review of WASH-1400 and the accumulated operating experience delineate those plant control operations which are likely to present an opportunity for beneficial operator intervention; and, those which are likely to present an opportunity for potentially harmful intervention. Characterize the system environment and equipment malfunctions that present favorable and unfavorable opportunities. Based on the foregoing, develop detailed event- and fault-trees covering the range of operator actions. Viewing the operators as components, develop alternate control systems which markedly reduce the liklihood of harmful intervention.

| FY 80 | 81 | 82 | 83 |
|---|---|---|---|
| 300K | 400K | 400K | 400K |

This is a category C proposal but may be related to current PAB efforts.

99 109

| Fission Product Tell-Tales | FY 80 | 81 | 82 | 83 |
|---|---|---|---|---|
| | 200K | 350 K | 350 K | 200 K |

Determine the feasibility of identifying the likely state of the fuel by monitoring the energy and intensity of prominent fission product gamma lines whenever there is a substantial release.

Category C

ARSR

REACTIVITY FEEDBACK ENHANCEMENT

BWR shutdown Reactivity Performance (Prompt Relief Trip) - determine effectiveness of PRT as proposed by GE.
(Issue #24, NUREG 0153)

| Category D | FY-80 | FY-81 | FY-82 |
|---|---|---|---|
| | 250K | 500K | |

Estimated duration - 2 (?) years

Category D

99 111

PROJECT TITLE

Investigation of Current Ft. St. Vrain Reactor Questions

- Power and temperature fluctuations
- Structural graphite oxidation
- High temperature metals behavior
- Accident analysis
- Flow distributions
- IGI requirements

COSTS

| FY 1980 | FY 1981 | FY 1982 | FY 1983 |
|---|---|---|---|
| 600K | 1300K | 1300k | 1000K |

This is a category D program.

FLOWING SODIUM LOOP FOR ACRR

This project is to design, construct and install a flowing sodium loop in ACRR to test fresh and irradiated pins beyond the point of clad failure.

| FY 80 | 81 | 82 | 83 |
|---|---|---|---|
| 1,500 K | 1,500 K | 2,000K | 2,000 K |

This is a category D program.