PURDUE UNIVERSITY
DEPARTMENT OF NUCLEAR ENGINEERING
WEST LAFAYETTE, INDIANA 47907

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June 26, 1979

PDR 9/13/79



Professor M. Plesset
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Dear Professor Plesset:

This letter is to express my deep concern for the manner in which we are responding to the TMI-2 accident. My thoughts are along the lines presented in my June 8 letter to Professor Okrent of which you are already aware. The June 19, 20 meeting of your ECCS subcommittee reinforced my views and I would like to continue with the present letter.

In my June 8 letter I argue on matters of philosophy and overall approach. Both you and Professor Okrent indicated, independently, that you would like to see more specific recommendations for practical implementation. I believe that coming up with such unilateral recommendations, before the matter of philosophy has been settled, may distract from the major goal by bringing up what I consider as the detailed aspects of the matter. I will venture into the area of specifics in this letter with the understanding that there are many ways to obtain the desired goal which can be equally acceptable as long as they satisfy the requirements of clear philosophy towards establishing and synthesizing mechanistic accident sequences, speed, and completeness.

I emphasize the philosophy because I am convinced no one within the NRC leadership appears eager to spearhead such an effort. As I have listed in my June 8 letter, I have been trying to instigate such an effort for a few years now working through the ACRS as well as through review group meetings of the WRSR. The fact that nothing came of it serves to support my claim. Along the same lines, I would also like to mention that the initial augmented budget as drawn by WRSR was presented to the ACRS TMI-2 subcommittee with a very minimal effort in this area. One month later as presented to the ECCS Subcommittee the budget was changed, in response to my criticism, from 0.4 to 1.4 million. This is an inadequate change especially since it became clear that the problem has not even been approached in the planning stage. Dr. Murley implied a game of "aimless" search when he made reference, while responding to my question of timetable for this activity, to a slow "turning stones around" process. More importantly Dr. Fabic, whose branch is supposed to be involved in this, presented "endless" lists of codes "developed," "under development," and "to be developed," he even discussed the rudiments of a code assessment methodology but did not volunteer any thought in the most important subject I am talking about, that is, code application. I want to make it clear that these comments

are not meant to criticize Stan Fabic; instead to point out that his branch has been charged with analysis (it is called System Analysis) and indeed it has done an admirable job in directing the development of the crucially important best estimate codes. On the other hand I am talking about synthesis of accident scenarios (sequences) including (but not limited to) man-systems interactions during the accident progression. Although I have argued many times in the past that some measure of synthesis can be very helpful in the analysis efforts as well, it would require a considerable shift of gear for the full blown effort that I consider necessary and urgent now.

The point of all the above is that TMI indicated the existence of cracks in our safety assessments. Many of us were aware of the *potential* existence of such cracks but misjudged the urgency of the problem in relation to achieving adequate R & D results (analytical tools) that could help pinpoint the deficiencies. Now we have the proof that this effort is overdue. Also we must realize that the job can be done well with less than perfect predictive capability. The iterative process of synthesis and analysis coupled with *systematic* presentation of results for continuous scrutiny in the technical community can only provide a degree of completeness ever-approaching the high level required in this business.

Two months have gone by since the TM-1 accident and as far as I can see we spend our time in *talking* rather than *doing*. In my opinion the nature of the problem is such that the analyst must be out in the field getting to know his system, and thus further diminish the opportunity for errors in predicting its response. This then brings me to my recommendations.

(a) The Task. Establish realistic accident sequences (scenarios), by postulating initiating events and man-machine-accident interactions; carry out to various degrees of degraded core cooling conditions, and systematize the area. Although probabilistic aspects have to be taken into account the emphasis should be in physical aspects and better understanding of the mechanistic accident sequences. No two reactors are exactly alike and a method to systematize and study the differences needs to be established. Identify weaknesses and deleterious circumstances, if any, with a goal to improving safety through improving: the systems, the diagnostics, the operator training and responses.

(b) The Leadership. Establish a Synthesis, or Code Application Branch in Dr. L. S. Tong's organization, to carry out the direction of the above task. Since a good direction will be benefitted by significant in-house work, this branch must be staffed with atypically large personnel. Establish a review group of experts including people knowledgable in systems as well as in codes and modeling, and preferably in both. This review group should be willing to devote substantial time to the effort, meeting no less frequently than once a month. Its members should be willing to also carry out independent assignments at home. Perhaps a 30% commitment would be appropriate. Strong interaction with licensing and inspection and enforcement would be essential A counterpart effort should be established by the NRC staff.

(c) The *Modus Operandi*. In addition to the Application Branch Staff and the Review Group each of the major contractors should dedicate research groups to this area. Although specific assignments for calculations and *study of the results* to support future calculations should be arrived at by consensus with all participating, initiative of groups, and individuals, should be encouraged for exploratory type investigations. Efforts should be made to systematize accident sequences, and thus establish a methodology for a systematic incorporation of the lessons to be learned to improving safety. It should be emphasized that this will be a results-oriented effort continuously striving to draw implications and make recommendations for *short term actions*.

(d) The Timing. The above efforts should be established *immediately*, with funds made available from current lower priority programs. The WRSR should make recommendations for such reallocations together with the impact projections. The charter of this effort must include significant milestones communicating the results to ACRS and NRR on a quarterly basis and a reasonably complete report within a year. Further in-depth studies are to continue for the subsequent several years.

(e) The Funding. Having established a realistic organizational structure with the above goals in mind a budget projection should be made, making generous allowances for computer calculation costs and/or computational facilities. As a minimum this should form the focal point of future budgets. It is expected that results from this task will be useful to direct future efforts for R & D by providing a perspective on priorities. The total LOCA/Transients budget should be examined thoroughly with a view for efficiency and economy.

I hope the above explains my ideas and goals sufficiently well. If you have any questions please call me.

Sincerely,

T. G. Theofanous
Professor

TGT:wb

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June 8, 1979



Professor David Okrent
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Dear Professor Okrent:

This letter is in response to your request for comments following the 5/31-6/1 meeting of your Subcommittee on the TMI-2 accident implications. There are many detailed points that I would like to make at some later time. However, for the purpose of emphasis and to avoid dilution I would like to concentrate, in this letter, in the major point of philosophy of approach in responding to TMI-2.

According to the office of Nuclear Regulatory Research the TMI-2 accident has brought up the need to better study the area between design basis accidents and core melt accidents. Based on this an extensive but rather diffuse list of task areas ranging from "accelerating development of transient and small LOCA codes" to "containment integrity under fuel melt conditions," was prepared with a total price tag of ~ 30 million dollars. Although I still believe, as I did in a 1974 letter to the ACRS, that better understanding ("probability of occurrence and consequences") of this intermediate area ("partially degraded conditions") is warranted I think it will be wrong to make it the initial focal point of our response to TMI. Instead, I believe, we need to look (in a more generic fashion) for safety deficiencies primarily responsible for TMI. In my opinion the answer to this question is lack of sufficient understanding of accident sequences (of not only small LOCAs but of the whole spectrum of sizes) including the whole breadth of physical phenomena associated with LOCAs and system/human interactions. This is like constructing event trees except with the emphasis in mechanistic details of accident progression (as determined from physically grounded analysis tools) *together* with the usual probalistic oriented aspects of component/human behavior.

A major and diligent effort would be required to produce useful results in this area. On the other hand such results would be instrumental in a number of areas: (a) indicating areas where further fundamental research and/or empirical information would have the greatest impact on safety; (b) providing a background against which operator training may be made substantially complete, including better elucidation of the type and kind of instrumentation crucial for correct operator responses; (c) provide the necessary basis for a realistic approach to the advanced code verification (assessment) efforts that is about to commence, and finally; (d) such studies will provide us with a better basis (than that available today) for a realistic approach to striking the appropriate balance between *prevention*, *mitigation*, *intervention*, and *estimation of consequences* for reactor accidents. Along these various lines of

defense verification of projections becomes increasingly more difficult. Unscheduled complications may always arise, hence major uncertainties in the projected behavior develop. Clearly, therefore, the research emphasis should be in the above order. However the demarcation lines and the absolute degree of emphasis need better definition.

I would also like to take issue with the attitude, expressed by many these days, that the main licensing thrust has been on "conservative" analysis while TMI points to the need of "realistic" evaluations. I think, in a more appropriate view of this situation, we should recognize that unless one knows the true phenomenology and sequence of events one is hard pressed, in many situations, to make "conservative" choices in the analysis. This has been well known in the past. The ECCS hearings and Appendix K implementation have many times pointed to this fact. This is precisely the reason that such large efforts have, and are continuing to be devoted to the development of best estimate Computer Codes for LOCA (and transients). Further it should be obvious that as the size of the break decreases and the time sequence of the accident increases, there is more opportunity for phase separation and large degrees of nonequilibrium (i.e. injecting cold water etc.) both being complicating and ill-characterized factors affecting the thermal-hydraulic response of the system. Also there is more opportunity for human and system interactions (i.e., actuating/deactuating systems and random systems failures) further complicating the sequence. I do not think we have failed to recognize the importance of all these things in the past. We failed instead in carrying out the relevant analysis, thinking and scrutinizing the results, to better understand the system response and identify weak links in systems and troublesome areas in human interactions. Such endeavors are difficult and not precisely definable in detail at the outset. The response of the system can be very complicated indeed. There has been a "natural" hesitation, therefore, to undertake major efforts in this direction in favor of a plug-and-chug approach with code computations carried out primarily for the purpose of obtaining a peak clad temperature. The excuse has been, at least given in response to my asking for such applications, that the analytical tools have not been adequately developed as yet. This may have been true five years ago, but it has become less true during the past 1-2 years. If we wait until the tools are completely perfected it will take forever. I believe that it is now urgent that any further analysis tools and code development be guided by appropriate "synthesis" of accident sequence studies. Like I mentioned in a 1977 letter to the ACRS we need to put major emphasis in scrutinizing "code results and accident sequences to provide the basis for an iterative synthesis-analysis process converging to the *actual phenomenology of interest to safety.*"

One can think of situations where operator intervention would be essential during the course of an accident. This will be particularly true for small breaks. Hence as the break size decreases the accident sequence becomes more complicated. Hence it is less clear what represents a conservative analysis choice and most importantly it becomes more difficult formulating a reasonably compact set of recommended operator actions. For this latter task, in any case, it is absolutely necessary that the operator have the appropriate

diagnostic tools and to relate, through analysis, the indication of these tools to the physically occurring processes. Hence the need for predicting actual (vs. conservative) system response increases as break size decreases. The difficulties of modeling and computations also increase. Incidentally I find the current B&W effort to provide a "plausible" explanation for the TMI events a step consistent with their capabilities but rather inadequate. Finally it will prove, I think, rather difficult to find appropriate facilities for assessing (or verifying) the adequacy of such computations. This is because the scaling problems become more severe. There are reasons to doubt, for example, that we can expect to learn much about small breaks from Semi-scale. Since such experimental programs need long lead times, I suggest that this issue also receive concentrated attention in conjunction with the accident sequence studies mentioned above.

Due to the time available between our subcommittee and the full ACRS meeting I am afraid this write-up is not as well organized or as clear as I would have liked. Please call me if you have any questions, and I will do my best to attend the meeting of 6/14-6/16.

Sincerely,

T. Theofanous

T. G. Theofanous
Professor

TGT:wb