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INTERNATIONAL WORKING GROUP ON FAST REACTORS

ELEVENTH ANNUAL MEETING

Bologna, Italy
17–20 April 1978

SUMMARY REPORT
Part III

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FOREWORD

The Eleventh Annual Meeting of the IAEA International Working Group on Fast Reactors was held at the Palazzo dei Congressi, Bologna, Italy from 17-20 April 1978.

The Summary Report (Part I) contains the Minutes of the Meeting.

The Summary Report (Part II) contains the papers which review the national programme in the field of LMFBRs and other presentations at the Meeting.

The Summary Report (Part III) contains the discussions on the review of the national programmes.

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DISCUSSION
of Mr. Vautrey's presentation

Dr. Tomabechi: How many fuel pins have been taken out from Phenix and how many failed fuel pins have you found amongst those pins?.

Mr. Vautrey: At the present time it is more than 40,000 and there is no single failed pin. But there were certain cases of fission gas release in Phenix without a disturbing effect on the functioning of the reactor. We never tried to identify such pins and there was no trouble with the operation. Therefore, I have said that there were no failed pins.

Dr. Smith: Just going back to your description of the modification to Rapsodie, you mentioned this arrangement for taking sodium samples, as I understood it, from a central position so that you could place a suspected sub-assembly in the centre and sample it. Is this sample from one position or from one of the central zones?.

Mr. Vautrey: The sodium sampling is adequate for the 7 central sub-assemblies. In order to check another sub-assembly you should bring it into a central position in order to take the sodium sample.

Dr. Smith: I would also like to ask about sampling for delayed neutron - I presume this is a delayed neutron sampling device?. In Super-Phenix I and II do you propose to have any individual sub-assembly sampling as we are at present proposing in CDFR, with a separate pipe from each sub-assembly outlet?.

Mr. Vautrey: You know of course that this is the case in Phenix and will exist in Super-Phenix. We do not intend to do this on Rapsodie because Rapsodie is after all a reactor where one can introduce a certain number of modifications but one cannot of course rebuild the reactor.

Dr. Smith: I was not concerned with Rapsodie. I just wondered in light of your experience whether in fact you are continuing to sample for individual sub-assemblies for future reactors and the answer is, I understand, yes.

Dr. Tomabechi: Concerning the sniffing device to detect fission gas from fuel pins, could you please tell us how many degrees of celsius you are going to raise the pins in order to get the fission gas out?.

Mr. Vautrey: Preliminary experiments have been carried out to study the system in-pile in order to make sure that one could in fact take part of the sub-assembly out of the sodium and leave it to heat up for a certain time without reaching excessive temperatures. I cannot give you any figures but we checked that during the experimental time the temperature of the sub-assembly does not go higher than the maximum tolerable temperature. In other words, that fuel in any event does not become at all damaged during that period of time.

Dr. Yevick: You indicated in your presentation that there is a possibility of using $2\frac{1}{4}$ Cr and 9 Cr materials and modular construction for Super-Phenix 2 and 3 steam generators. In this connection do you envisage testing these units in Les Renardieres and if so are there any plans for the possibility of increasing the size of the testing of Les Renardieres?.

Mr. Vautrey: We are carrying out tests on Les Renardieres but we are not at all thinking of increasing power of that installation.

Dr. Kessler How many fuel elements of Rapsodie and Phenix have been reprocessed up to now and were in Marcoule or in La Hague?.

Mr. Vautrey: Rapsodie fuel is being reprocessed at La Hague in the pilot plant called AT1 for a certain number of years. There were a number of papers on it and it was already stated with regard to Rapsodie that the fuel cycle is closed. With regard to Phenix, reprocessing has been done both at La Hague and in Marcoule I have no exact figures but as far as I know reprocessing of a certain number of some sub-assemblies was involved here.

Dr. Däunert: I have a question concerning your study on cost reduction. Do you have any idea what the potential of cost reduction could be in the future?. As you know, we have under way similar studies in the frame of SNR-2. By parametric studies it was found that e.g. valves, will contribute a share of about 20% of the construction cost and the construction cost could be decreased reasonably by decreasing the diameter of the piping, in our case of the loop design. Repeating my question, have you up to now any idea what the potential of cost reduction could be for Super-Phenix-2?.

Mr. Vautrey: As I stated earlier, the things that one is really trying to achieve in the final analysis, and I believe which is much more than producing a certain cost reduction, is to study the reactor with its primary components, core, pumps, IHX, etc., in such a way as to be able to put in a unit of the same size, a higher power rating, a higher power installation. Then for the same price you could produce more MWs.

Dr. Smith: I wonder if Mr. Vautrey could comment a little more about the size of the sub-assemblies for Super-Phenix both 1 and 2. He has said that the number of pins has gone up to 271 against 217 and I presume this means a larger sub-assembly rather than smaller pins. If one does this one saves on refuelling time, but you get into more difficulties because of the decay heat when unloading the sub-assembly from the reactor. This may cause a slowing down of the unloading process and one may also get into problems in transport and at the head-end treatment plant. I wonder if Mr. Vautrey could make any more comments on the optimum size of sub-assemblies and how he arrived at this particular size.

Mr. Vautrey: The pins for Super-Phenix have a diameter which is much smaller than in Phenix. It is about 5.5 mm. instead of 8.65 mm for Phenix. The size of the sub-assembly has not been greatly increased.

Mr. Balz: In the context of problems still to be solved for Super-Phenix, you mentioned the safety cooling system. Could you expand on the kind of problems you have still to solve?.

Mr. Vautrey: The possibility of getting out the residual heat, which according to the safety criteria should be possible if one has lost all normal heat evacuation systems, is the safety cooling system.

Phenix has a water circuit system which is in the safety vessel walls and which, thanks to a semi-transparent heat insulation on the main tank, evacuates power by radiation through those water circuits. As far as Super-Phenix is concerned we saw, because of the increase in size and because of the emissive properties of the double vessel, which is made of stainless steel, that it would be better to use a supplementary system, another system for getting away that residual power in the case of having a complete break down of the normal heat removal system. We are going to introduce some small ancillary exchangers which we call flasks or bottles, with external air heat exchangers. So you will have safety heat removal circuits with exchangers submerged into the primary sodium.

Dr. Yevick: You explained some of the organizational structure for Super-Phenix in the European framework. Are any thoughts being given as to what organizational structure would be used for Super-Phenix 2 and 3?.

Mr. Vautrey: The client for Super-Phenix 2 and 3 will be the EDF and the order will be, of course, put to NOVATOME and the CEA will remain through the SERENA the licenser of the system and of course the research and development organization for all R&D that has to be done.

Dr. Smith: Could I ask another safety question about Super-Phenix 1?. How are you going to present the case on very improbable hypothetical core disruptive accidents?. What are you going to say about the strength of containment relative to core disruptive accidents in the safety case?.

Mr. Vautrey: The strength of the structures is calculated in any case. The studies under way show us more and more that the hypothetical accident is not very probable and what we do hope in the very near future will be to simplify things so that we can prove that hypothetical accident has a very low probability.

Dr. Smith: I would like just to come back to this question. It is undoubtedly also going to be the same line for the CFR, that the probability of these accidents is so low that they possibly will not be considered at all. But, since a licensing organization is charged by the Government with making reactors as safe as possible and not just sufficiently safe, there seems to be a legal requirement for having a strong containment. The NII are enquiring into these hypothetical accidents. It is very hard, we think to pick with any justification on any particular level of accident because they are all so improbable anyway. I just wondered whether you were saying that the containment was capable of resisting a certain level of accident or whether you based your case entirely on the improbability of such an accident at all. The latter might be a sounder basis, we feel, but hard to follow.

Mr. Vautrey: There is a very low probability of an accident of this kind. We hope that by some date in the future we will be able to design fast reactors to be simpler and to have less demands as far as this kind of accident is concerned. But for the time being our structure is such that we do have to take it into account.

Dr. Däunert: I would like to comment on Dr. Yevick's question. In my presentation there is a picture which gives a survey of the various European organizational connections between governments, vendors and research centres. There is an intention to pool all the know-how in order to use it for future construction of fast breeders. The know-how pooled in a license company named SERENA will also be used for Super-Phenix 1 and 2 as well as for SNR-2. Its application is only a question of sharing license income and license fees. The only question up to now is how a company from the utility side would be organized for the construction of Super-Phenix 2 but the contractual network up to now is a clear intention to go ahead together also beyond Super-Phenix and beyond SNR-2.

Mr. Vautrey: I do indeed agree with what Dr. Däunert has said and that the pooling at every level(research, engineering, industry)which has come about within the framework of the signature of the European agreement will be felt in future reactors. I just gave the most elementary outline. This cooperation is going to continue for future power stations.

Dr. Welch: I should like to return briefly to the question of reprocessing. Mr. Vautrey said that reprocessing of Rapsodie fuel has been going on for several years. This, I think, is highly enriched uranium or enriched uranium only, and several Phenix sub-assemblies have been reprocessed. Did any of these contain plutonium, do you know?.

Mr. Vautrey: The Rapsodie fuel is made of highly enriched UO_2 (60-65)% and 30% PuO_2.

Dr. Welch: You are saying that some of the Rapsodie fuel contains plutonium and has been reprocessed?.

Mr. Vautrey: Yes. All the Rapsodie fuel is UO_2-PuO_2

Dr. Smith: We had a discussion on heterogeneous cores at the Optimisation Conference in London. I wonder if Mr. Vautrey could say anything about any future developments as to what type of heterogeneous cores they think are the most interesting?. In particular, we feel that the core with layers and horizontal heterogeneity has disadvantages from a safety point of view if you have a melt-down.

Mr. Vautrey: At the present time the heterogeneous cores, which we are especially studying, are radial heterogeneous cores with concentric annular rings of fissile and fertile sub-assemblies. Other configurations or geometries are being thought of and in particular one that we call the axial-radial heterogeneous core in which you would have in the same sub-assembly fissile material and fertile material at the centre. But I would like to repeat that the reference design is the radial heterogeneous core with concentric rings.

Dr. Smith: One of the disadvantages of heterogeneous cores that concerns us is that if you put blanket elements in the core you necessarily get a wide range of powers and temperatures from these element during the life of the core. This can lead to making the thermal striping conditions above the core much worse than in the normal core. Could I ask whether you are developing any means of minimizing this, such as variable gags or whether you are able to deal with the more severe striping because of the heterogeneous core?.

Mr. Vautrey: A question of this kind is still rather premature. Heterogeneous core obviously does bring up thermal question in particular. But you referred, I believe, directly to thermal striping. As regards the thermal striping we are not much worried really.

DISCUSSION
of Mr. Häussermann's presentation

Dr. Khodarev: Would you like to comment on the NEACRP activities?.

Dr. Häussermann: Unfortunately, I am not aware of the detailed activities of the NEACRP because it is not in my division and I am not involved in this work. I will send a written report to you for distribution amongst the IWGFR members.

Dr. Yevick: Does the Mol experiment contain vented fuel?.

Dr. Häussermann: Yes, it is a vented fuel.

Dr. Yevick: What is the philosophy with respect to proceeding with discussion on a demonstration plant when there is a large lack of experimental facilities in gas-cooled fast breeder areas?.

Dr. Häussermann: This is a delicate question and I want to be cautious. We are at present in the Coordinating Group just discussing our future course of action. The present mandate of the coordinating group is finishing in the autumn of this year. At the end of this week we will have a discussion about our future plans. The proposal to go ahead with design work for demonstration facilities has been made on several occasions but has not found unanimous support. At present we think it is premature to talk about this question, but may I ask our chairman, Dr. Däunert, who is also here, to give complementary information on that item.

Dr. Däunert: I have to be very careful, Dr. Yevick, not to anticipate results of a discussion which will be held on next Thursday/Friday but I think the principal understanding of this group was that there are countries having a limited amount of R&D work in the gas-cooled fast breeder field, not sufficient to go ahead on a national basis but worthwhile to keep it alive by international exchange and cooperation. We never understood in this group the nucleus for the construction of a power plant.

Dr. Yevick: Is this OECD coordinating group familiar with the gas-cooled fast breeder developments in the USSR?.

Dr. Häussermann: The group is familiar with the USSR developments not through direct information to the group - the USSR not being represented in this group- as it is an OECD group. However, from time to time we have joint meetings with the IAEA in order just to facilitate exchange between the USSR and the Coordinating Group. Such a meeting is under discussion for the end of the current year or the beginning of the next year. There is a proposal which has been made in the IAEA International Working Group on High Temperature Reactors to have a joint specialists' meeting between the Coordinating Group and USSR representatives and from other countries which would like to participate and to exchange information. Such a specialists' meeting was already organized once some years ago in Minsk.

Dr. Däunert: I have a question to Dr. Inyutin. Some weeks ago I heard some rumours about a revival of a specific type of a gas-cooled fast breeder in the Soviet Union. Could you give me some more information about the studies of Mr. Krasin?.

Dr. Inyutin: At the Nuclear Energy Institute of the Byelorussian Academy of Sciences a project for 300 MW(e) gas-cooled breeder reactor BRIG-300 is being developed and a report on "Basic Performance Problems and Prospects for 1200-1500 MW gas-cooled Fast Reactors with Dissociating Coolant" was presented at the Salzburg Conference. A decision to build the BRIG-300 has not yet been taken.

Dr. Yevick: Have any studies been made by this coordinating group with respect to the impact of gas-cooled fast breeders upon the future electrical energy economy fueled either with the plutonium or with uranium?.

Dr. Kessler: About three years ago we performed at Karlsruhe a study comparing different fast reactor types including also the gas-cooled fast breeder reactor and their impact on the uranium consumption as a function of energy needs. The essential result is that the gas-cooled fast reactor has a better breeding ratio compared to the oxide fueled LMFBR but also a larger fissile inventory. Therefore, a gas-cooled fast breeder reactor needs a longer time to be introduced into the energy economy and does not lead to a lower uranium consumption than LMFBRs.

Dr. Yevick: Is this based on a plutonium gas-cooled fast breeder or does it include a uranium fueled reactor?.

Dr. Kessler: It was based on plutonium coming from light water reactors.

Dr. Smith: I would just like to remind people, as far as the CSNI is concerned we have in past years decided that specialists' meetings on safety would not be considered in our list of meetings and we could rely on CSNI to arrange this. I think that criteria for choosing specialists' meetings topics has changed slightly. The other point I would like to make is on gas-cooled fast reactors. Very little work is going on in the UK at present but there has been one appeal to people to have talks about very high burn-up gas-cooled reactors which can be possible perhaps because of the higher breeding gain of these reactors. I would like to ask if any studies have been made of particularly high burn-up fuel and I am thinking of above 20%?.

Dr. Häussermann: We have not made such studies. But, I should say that in various contributions which the member-countries make to the work of this group, this is considered from time to time, but the group itself has not made any specific studies in this field. Concerning the safety, I have no comments on the CSNI criteria for selection of specialists' meetings because it is out of my area of activity.

Dr. Kessler: Design studies on gas-cooled fast reactors, which were performed in the FRG, are having similar burn-up ratios and similar rod powers as the oxide-fueled LMFBRs. I would be extremely surprised if a fuel element going up to 20% burn-up with this type of fuel would be feasible.

DISCUSSION
of Dr. Däunert's and Kr. Kessler's presentation

Dr. Smith: Could I start at the back on this in-service inspection business which is a topic to which we have also given a lot of thought. For critical in-reactor structures, if there is any concern about reaching critical crack sizes it appears to us that the critical size of flaws in stainless steel weld metal could be very small and perhaps not possible to detect by inspection techniques inside the reactor. Have you any comments on what sort of crack sizes for which you are looking?.

Dr. Kessler: It is extremely difficult for me to give you an answer because I am not sure if we are already as far that we can define it. We have initiated the programmes on welds and the formation of flaws in welds but at the moment I don't know what the critical sizes are for which people are looking in the components.

Dr. Däunert: Perhaps I can help you Dr. Smith. This depends on the method of inspection of steam generators and IHXs. We have developed methods whereby we can come to detect crack in the order of a tenth of a mm.

Dr. Smith: That sounds a very good performance. Would that type of crack detection be possible for structures inside the reactor vessel after ten years of operation on critical structures if there are any?.

Dr. Kessler: I will send you an answer in written form but I have a feeling we are still in the discussion process. Project people still hope that they can inspect critical plates and critical parts of the internals. At the moment we are preparing for that.

Dr. Smith: Perhaps we could ask for comments on this problem from other countries. I think first of all I would rather not get involved with talking about individual reactors but put the question in a sort of a general manner. In some fast reactors there are structures which could theoretically fail suddenly. One example of this is a core support structure which would let a core drop off its control rods and another possible example is the inlet pressure plenum where if a large piece falls out there is such a sudden drop of pressure, the core would melt before you can shut the reactor down. In safety analysis it has to be ensured that this source of thing cannot happen with an appreciable probability; the probability of this happening has got to be 10^{-7} per reactor operating year or less. So you have to have some argument to show this. One line of argument would be that the structure is carefully inspected beforehand and there are no cracks in it and it can be re-inspected in suitable intervals and there are still no cracks in it. Another line of argument is in fact to design the reactor so there are no structures which, if they failed in this way, would produce a catastrophic result. That very possibly can be done perhaps by producing redundant structures in which case you have got to know that the first leg of your redundancy has failed. Alternatively it may be possible to do it in some other way by special construction, for example, bolted constructions are possibly less liable to propagation of cracks. We at one stage were thinking very much about the inspection procedure but we have been a little disappointed by what has been possible. We are tending to think rather more of designing either redundant structures or avoiding the use of any structures whose sudden failure could lead to a catastrophic safety problem. I am not talking here about failures which might cost you a lot of money to repair and might have a measurable probability of happening but have no major safety implications. I am talking about these imaginary accidents with very low probabilities, but, for which an argument has to be made to the licensing authorities. I wonder if we could have comments from the various countries on how they see this discussion. In some way it is similar to the postulated failure of light water pressure vessels.

Dr. Yevick: I have been working on sodium-cooled reactors since 1951. I have not yet seen any reactor that has been built in which there is full accessibility, full inspectability, full replaceability and full repairability. This is a serious defect in design. Will licensing authorities for commercial reactors require less than this?. Licensing authorities for light water reactors business are insisting on full inspection. They will probably insist on having full inspection for LMFBRs. One of the problems is that if a system is drained and some of the shielding removed to permit inspection of the internal vessel welds there still remains a film of sodium. There would have to be a method for removing the sodium. This is an Achilles heel for sodium-cooled reactors that will have to be faced in the future. Designers have good intentions that when they start design that they are going to have provisions for inspection etc., but when the design is completed and the plant is built, it is not there.

Mr. Vautrey: I have not got anything substantial to contribute. For the Super-Phenix reactor inspection problems are taken very much into account and the design of the reactor components takes the maximum account for that. On the other hand inspection techniques and the necessary devices have been very broadly developed in the CEA and will be used on Super-Phenix. But this is a matter which needs further consideration.

Prof. Pierantoni: When you are referring to the core surveillance instrumentation you said that the SNR-300 fuel sub-assemblies are equipped with four thermocouples. Are these sub-assemblies equipped with thermocouples or some of the mechanisms equipped with the thermocouples?. How do you connect the thermocouples?.

Dr. Kessler: We have a so-called instrument plate above the core. The thermocouples are inserted from above through a so-called cable-tree to the plate. So thermocouples are inserted in instrument plates and in the upper part of the heads of the sub-assemblies.

Dr. Däunert: There was an essential effort in our R&D programmes to perform experiments on the cross-flow on the head of different elements to get a reliable device for temperature measurement without going directly in the fuel element.

Dr. Yevick: On page 18 you refer to extending the test of creep rupture from 75000 h. to 200000 h. and then you indicated that you had tested creep-rupture of steel in sodium for a maximum of 3000 hours. Do you have a method of extrapolating from air to sodium to determine what sodium corrosion effects would exist for the long period of 200000 h. or more?.

Dr. Kessler: I must disappoint you. We are running the experiments in air over 200000 h. In parallel we will be running the experiments under sodium at least over 10.000 h. We hope then to find methods for the extrapolation of experimental results from test under sodium to longer time periods.

Dr. Smith: I have not had time to read through this material data. I wonder if Dr. Kessler could say from those results which he already has, and which are presumably incomplete, what sort of materials you envisage that would most likely be used for pin cladding for wrapper and structural materials in later reactors, as it looks at the present?.

Dr. Kessler: At the moment the reference material for SNR-300 claddings is 1.4971, a titanium stabilized austenitic steel. We have also under investigation the so-called 1.4981 which is the reference steel for SNR 300 wrappers. The latest results indicate that 1.4981 is swelling more than 1.4971. Therefore, 1.4971 might become our reference steel for both clads and wrappers for the future Mark-II cores of SNR-300. In addition, we have a programme on advanced steels. There we are looking first of all for small variation of the 1.4971. We are investigating also higher nickel content alloys. We have a small programme on ferritic steels and at the Nuclear Centre MOL dispersion ferritic steels are investigated. As components structural steels we had to introduce 1.4948, a 304 type stainless steel, and we had to verify the 1.4948 steel within the licensing procedure. For almost two years an analysis is going on as to whether we should go over to 1.4919, a 316 SS type steel. The analysis showed only little advantage for some of the mechanical properties and we did not take the final decision yet, although we are aware that other projects have already taken the decision to build a primary system with 316 SS. For the steam generators we have the same movement going from $2\frac{1}{4}$ Cr steel to the higher 8 to 12% Cr content steels. We did not take a final decision there, but we have these steels under active investigation for the future commercial reactors.

Dr. Smith: Another query I had on page 23 where you are studying the course of core disruptive accidents using thermite mixtures, I think. I just wonder whether there are problems in this in the gas produced by the thermite similar to the problems we had with thermite mixture intended for fuel-coolant interactions. In actual practice there would be some gas presumably from fission products but one tends to get rather more from these thermite mixtures.

Dr. Kessler: I know these problems which you had with your Q^* experiments. We hope to overcome this problem.

Dr. Yevick: Where is sodium fire facility located?.

Dr. Kessler: It is located at Karlsruhe.

Dr. Smith: You mentioned the containment system of SNR-2 is to be on a different principle from the reventing principle of the SNR-300. I wonder what are the reasons for changing the style?.

Dr. Kessler: One of the reasons is that the reventing concept is rather expensive. Furthermore in spite of the fact that design concept looks rather consistent and good at the moment we have a lot of arguments with the licensing authorities about the reliability of those exventing blowers, which have to take over after an HCDA to evacuate the space between the two outer shells during the phase of time from 0 to about 12 to 15 days. One problem which came up there is, for instance, that we have to deal with a lot of sodium aerosols and sodium aerosols would affect the blowers. We had to do special tests to demonstrate that SNR-300 blowers work reliably in such an environment. Therefore we intend to find a system which is not that complicated.

DISCUSSION
of Dr. Balz's presentation

Dr. Yevick: Let me ask you some questions with respect to the organization of Fast Reactor Coordinating Committee. Who are the members of that Coordinating Committee?.

Dr. Balz: It is the general rule that each member country may designate one representative from each party interested in fast reactor development: governments, research centres, designers, licensing authorities and utilities.

Dr. Yevick: To go beyond that, how about the Safety Working Group - how is that organized?.

Dr. Balz: The composition of the Safety Working Group is the same as that of the Fast Reactor Coordinating Committee.

Dr. Yevick: All this work that you have been describing here, how will that determine as to how the research and development activity will continue?. Who sets the policy and makes a determination of the objective and how is all this information distributed to the members?.

Dr. Balz: The Fast Reactor Coordinating Committee was set up by the Council of Ministers with the aim to promote coordination and cooperation between the Member Countries in the field of fast reactor development. As you know, the Fast Reactor Coordinating Committee set up two working groups in fields in which it considered collaboration particularly indicated, namely in the field of safety and codes and standards. One task of both groups is the exchange of information on current national programmes. The discussion of these programmes can well lead to recommendations for new activities which may be executed in national programmes or by our Joint Research Centre. As far as the distribution of documents produced by these groups is concerned, it is limited to the members of the group who are authorized to circulate them to people belonging to the party which they are representing. The results from our own research activities are available to all member countries.

Dr. Yevick: Right at the beginning you described activities for preparing commercialization in the frame of the Fast Reactor Coordinating Committee. The second item is the execution of your own research programme at Ispra. What is the difference between the two activities?.

Dr. Balz: Both activities are to some extent complementary. The main task of the Fast Reactor Coordinating Committee (FRCC) is - as had been said before - the preparation of the commercial introduction of LMFBRs by a better coordination and cooperation between national programmes.

The Commission's own research programmes which are financed by the Community, are of a more basic nature and are complementary to the national programmes.

Dr. Yevick: How do you obtain the money to carry on these programmes?.

Dr. Balz: The budget allocation for our research programme is a rather complicated procedure. Any budget decision is taken by the Council of Ministers. Its decision is based on programme proposals prepared by the Commission which before submission to the Council are discussed by a number of Committees in which the member countries are represented.

Dr. Däunert: I would like to add some comments, Dr. Yevick. This is, I think, a very specific European problem which is not so easy for the United States to understand. The first thing which should be explained is that the Coordinating Committee is not a committee which has its own budget and can introduce projects in the sense in which we discussed it here. But we have common problems in Europe - for instance, a problem if we construct the SNR-300 at Kalkar. It is so near Belgium's borderline and that of the Netherlands that an incident could influence these countries and if the French are going to construct a power station at Fessenhein it is so near the Rhine river that an incident can affect the FRG. On this account we try to arrange ourselves in a way that we have no different safety standards, which would lead to political difficulties. So with regard to safety, the Safety Working Group has a function on the basis of good will to arrive at an entirely common understanding of safety in Europe. You don't have such a problem if you are going to construct a reactor on the borderline of one of your States, because you have only the one NRC. The other item concerning the common research centre, on which I think we should not go too much into detail here, is a very difficult procedure on how the money, which is being paid by all the countries, and is not only related to reactor development, is distributed and for what task. By a certain procedure some money is given to Ispra to perform an experimental programme.

Dr. Yevick: In connection with our discussion this morning on design criteria you indicated that there is a Codes and Standards Working Group which terminated the evaluation of some future activity. Could you expand on that a little bit more as to what this Working Group is trying to do on codes and standards?.

Dr. Balz: The Codes and Standards Working Group had the mandate to compare existing design codes and standards, to evaluate existing differences and to promote activities which could lead to a consensus on the evaluation of existing differences. So far the group detected existing differences between codes and standards in the following area:

1) Manufacturing Standards and quality control,
2) Structural analysis and design calculations,
3) Materials and
4) Classification of components.

In a next step a detailed evaluation of these differences will be undertaken. Probably Prof. Pierantoni, who is the Chairman of the CSWG would like to add something.

Prof. Pierantoni: Design criteria are essentially related to comparison of the code case 1592. We are trying to make comparison in different countries about code case 1592. We are now awaiting the commission's decision because we have agreed it is almost impossible to carry on the activity only in the frame of a committee and we have asked for some money for contracts. This is the problem we now have to solve in order to go on in the direction of analysing the existing code. We are now concentrating all our efforts in the field of design criteria not specifically related to safety.

DISCUSSION
of Dr. Inyutin's presentation

Dr. Smith: Are these formulae on inter-channel mixing available in your paper?.

Dr. Inyutin: These formulae are not contained in my report but are available particularly through bilateral cooperation. I did not intend to write a scientific report. This is just an observation and description of the work which has been done.

Mr. Vautrey: I am looking at the part which I could not follow very well where you talk about irradiation at low temperature with respect to dislocation loops.

Dr. Inyutin: Tests have been done on the influence of operational mode of the reactor, temperature gradients and interaction of materials with coolant on the development of porosity and accompanying phenomena. It has been seen that the inconsistent mode of the reactor operation has a great influence on swelling of steel. Irradiation of steel at the initial period of the reactor operation, when the reactor is still working at low temperatures, leads to an intensive development of dislocation loops and these loops serve as the drain for defects and the existence of these loops leads to the reduction of swelling. Particularly effectively they cut down on swelling at the temperature of 360-400°C.

Dr. Tomabechi: I learned from your presentation that in one of the secondary cooling systems of BOR-60 an electromagnetic pump was installed replacing a mechanical pump. I would like to ask why did you install this electromagnetic pump instead of the mechanical one?.

Dr. Inyutin: Three or four years ago we discussed at the Annual Working Group Meeting that several countries were doing work to increase the power of electro-magnetic pumps. And a basic argument in favour of electromagnetic pumps was the simplicity of manufacture and operation compared with centrifugal pumps. In BOR-60 we used them particularly for testing.

Dr. Smith: Could I ask two questions about BR-10?. First of all, I think you said it was running at 5MW which I think is below its rated power. I wonder what is the limit to the power, what is the reason for only running at 5 MW? Is this control rod bowing, which I believe was one problem you had?. Secondly, you mentioned pins which got to nearly 11% burn-up. Could you give us any details of these pins in terms of density, diameter, etc?.

Dr. Inyutin: The reactor BN-10 has already been in operation for a long time and some of the internal components have collected fluence which is closed to $10^{23} n/cm^2$. There is a certain amount of concern from the safety point of view as to whether the reactor can work safely at a high power. Consequently, we have recently reduced the power of reactor BR-10 and you might have noticed that I said in my paper that calculations are being carried out into the possibility of changing the reactor vessel, the core and the modernization of some of its equipment. In other words we feel that under the condition of the irradiation of the internal parts of the BR-10 reactor we are coming close to the time when this internal equipment will necessarily have to be changed.

Now about the second question. As I remember the outer diameter of the fuel pellet is 4.0mm and the diameter of the hole in the pellet is 1.0mm; the length of the fuel pin is 320mm.

Dr. Smith: A small point perhaps which I think is in the translation, if Dr. Inyutin could clear this up. We had the term "utilisation factor" in the translation. We have terms like availability factor and load factor and so on. Could you just define'utilisation factor': is this the proportion of time available or a proportion of time on power?.

Dr. Inyutin: With respect to reactor BR-10, 63% is the time during which the reactor has been working at various power levels. Utilization coefficient for reactor BOR-60 is 59% if you use the same definition. Utilization coefficient for BN-350 averaged 88% for the last two years.

Dr. Smith: In this 88% the time for which the reactor runs at power divided by the total number of hours in the year or is it divided by the total number of hours less the refueling time?. Does it take into account refueling or maintenance time or is it just a fraction of the toal time?. It is just a question of definition and not the actual number.

Dr. Inyutin: This is the time for which the reactor runs at power divided by the total number of hours in a year. BN-350 reactor has been in operation at power level 650 MW(th) practically all that time (88% of two calendar years) with the exception of short shut-down-start-up periods for refueling.

Dr. Yevick: Your presentation indicated that one of the loops of BOR-60 is operating with a Czechoslovakian type unit and the second loop is operating on the sodium to air heat exchanger. It has been my understanding that you were to test a BN-600 model steam generator in BOR-60. Could you give us the status of this test?.

Dr. Inyutin: We are planning to test this steam generator on BOR-60 but cannot really tell you what the state of things is at the present time because I am not familiar with the time schedule.

Dr. Yevick: At the symposium on the status of the BN-350 a statement was made that the erection of equipment for replacing the steam generator on the BN-350 was under way. Could you tell us the status of this?. Are all of the steam generators to be replaced and what type of units are to go into BN-350?.

Dr. Inyutin: The state on the steam generators of the BN-350 is as follows: At present time five steam generators are in operation. One of them is working without a single incident ever since the reactor was started up and four steam generators were repaired after they underwent incidents. As regards the sixth loop a Czechoslovakian built steam generator should be installed and it is possible that the assembly of this steam generator will be concluded this year.

Prof. Pierantoni: When you speak about the study in the long terms of the BN-1600 reactor, do you consider the possibility of having a horizontal vessel?. This means also the possibility of having horizontal sub-assemblies. What do you mean by the horizontal vessel?.

Dr. Inyutin: Horizontal placing of the reactor vessel does not mean that you must have a horizontal placing of the fuel elements and the sub-assemblies. I can show you a preprint with this horizontal design for the reactor. The core will be centrally placed and the circulation pumps and the IHXs will be installed in a long sort of casing. So Professor Pierantoni, let me show you this diagram.

Dr. Smith: Have you any plans for when the BN-1600 might possibly be started or completed?. Are there any dates or is it just an idea at this point in time?.

Dr. Inyutin: No specific date so far has been established for beginning the construction of the BN-1600 reactor. We consider it would be appropriate to take a decision about that after we have started up and operated the BN-600 over a certain period of time.

Dr. Smith: Going back to the BN-350 I think it was originally designed with one spare loop so that it should be able to operate at full power with five loops. What, at the present time, is actually the limiting factor in determining the output of the BN-350?.

Dr. Inyutin: You are quite right. However, having some experience with emergency situations on the reactor BN-350 we consider at the present time that it would be better to operate for a certain period of time on the power level which we have achieved, so as to show the efficiency and reliability of power producing fast reactors and to demonstrate that it can be well controlled, handled properly and it is safe. I said in reply to Dr. Yevick that at the present time the sixth steam generator is being installed. We don't want to look at the question of increasing the power before we have installed the sixth steam generator. We want to have a sort of reserve in the steam generator's capacity before considering the question of further increasing the power.

Dr. Smith: What you are saying is the limit is in fact the steam generators and not any part of the reactor because you had no incidents on the reactor, only on the steam generators. Therefore, the power limit is in the operation of the steam generators. Is that right?.

Dr. Inyutin: Yes, you are absolutely correct.

Dr. Welch: We have seen some reports about Russian gas-cooled fast reactors cooled with N_2O_4. Would you like to say anything about this, Dr. Inyutin?. How does it compare on time scale with the BN-1600?.

Dr. Inyutin: Research on this type of reactor is being done in the Soviet Union and you can read about this in various reports and articles. A design of a demonstration reactor BRIG-300 with electrical power 300 MW is being developed. But a decision to build this reactor has not yet been adopted.

DISCUSSION
of Dr. Tombechi's presentation

Dr. Däunert: First of all, I would like to congratulate you, Dr. Tomabechi. One more fast breeder is now in operation in Japan. I have some questions first concerning the JOYO reactor. In one part of your report you mentioned that you are going to enlarge the storage capacity of JOYO and if I understood this correctly the capacity will be sufficient for one full core loading. This seems to be sufficient for one or one and a half years of operation. What are you doing then?. I experienced that you in your country have a similar behaviour of the licensing authorities. Have you indications up to now that you will be urged to find a solution for the spent fuel of JOYO in order to be allowed to go ahead with the operation and have you any idea how to manage this in your country?.

Dr. Tomabechi: The regulation of the licensing authorities requires to leave always one full core sub-assembly space in the storage facility in order to be ready for any emergency use. In other words, on any occasion all the sub-assemblies should be able to be taken out from the reactor to the storage. Our reactor core has about 300 sub-assemblies including breeder sub-assemblies. Therefore it means we must have always 300 sub-assembly storage capacity available. This is why we decided to install a new spent fuel storage facility which has 600 sub-assembly storage capacity. At the moment we have a storage facility which can accommodate only 200 sub-assemblies. This is the original idea to start construction of a new spent fuel facility. Our licensing body likes to see a way of reprocessing spent fuels to be fixed before we start operation of the reactor. But, as you know, under the present circumstances of fuel reprocessing in the world we should not be too optimistic and we will have to explain to our licensing body that unfortunately we don't have a reprocessing plant at the moment in our country which is capable of reprocessing fast breeder fuel. We will explain at the same time that if we finish the construction of a new spent fuel storage facility we will have storage capacity of spent fuels of 3-4 cores and it will permit us to operate the reactor at least for a few years to come. Does this answer your question, Dr. Däunert?.

Dr. Däunert: Not completely, Dr. Tomabechi, but I would not like to ask you a question which you cannot answer. My interest comes from the side that we are in a similar situation with KNK. Our authorities will ask for the concept how to get rid of the spent fuel. This must not necessarily be reprocessing because it makes no sense to install a reprocessing facility for one 18 MWe reactor in the FRG. So we are looking for an intermediate storage outside of the reactor.

Mr. Vautrey: If I have correctly understood, the total storage capacity would be for 3 or 4 cores. Is that right?.

Dr. Tomabechi: I have circulated a brochure of JOYO and the exact number of the fuel sub-assemblies in the reactor is given in this brochure. As I said, the present storage capacity is only for 200 sub-assemblies. We will have an additional 600 sub-assembly storage capacity if the new facility is completed and all together we will have 800 sub-assemblies storage capacity. So it correspondends to about three to four cores.

Dr. Smith: Are both of them going to be air storage or I think going to be sodium storage?. How actually are you preparing to store your elements for a long period?.

Dr. Tomabechi: All the sub-assemblies coming out from the reactor JOYO are washed and canned and stored in a water pool. We don't have any other route to the storage facility.

Dr. Smith: What is then the can. When you canned them are they filled with helium or air?.

Dr. Tomabechi: They are filled with water.

Dr. Smith: Have you any designs or plans for transport flasks for moving the spent fuel from MONJU?. I believe it will have to be moved from the MONJU site. How is this to be done?.

Dr. Tomabechi: There is a R&D programme to develop a transport cask but I don't think the design has been fixed. Just now we are studying various possible transport casks.

Dr. Smith: Could I ask Dr. Inyutin whether there is any information from the Soviet Union about the design of spent fuel transport casks for BN-350 or BN-600?.

Dr. Inyutin: A report was submitted on the transport of various types of fuel at the Salzburg Conference and as far as I remember there was a design put forward there for containers for transport.

Dr. Smith: I can't remember that there was much detail about fast reactor transport flasks at Salzburg. Can you remember whether you proposed to transport in sodium, water or in gas?. I think most of the Salzburg papers were about the thermal reactor fuel flasks.

Dr. Inyutin: I think that the transport flasks were intended to be sodium filled but I am not sure about that, not a hundred percent.

Dr. Däunert: Dr. Smith, perhaps this will help in answering your question. We in the FRG have developed a transport flask within the frame of the company "Transnuclear" which has a sister company in Great Britain. There should be information in the UK about these transport flasks.

Dr. Yevick: I have two questions. You indicate that your expenditures for the fiscal year were increased to 24 billion yen. Was this just operating cost or did it include some capital cost for constructing MONJU?. And my second question is: have you made any late estimates on the construction cost of MONJU?.

Dr. Tomabechi: The budget for 1978 fiscal year is 24 billion yen. This does not include the wages of the personnel of PNC. It does include construction cost, for instance for a new spent fuel storage facility, and money to be given for research contracts to various organizations and so forth. It does not include the construction cost of MONJU itself but it includes money for the necessary preparatory work at its site.

Regarding your second question, we have only a very rough figure. We have not negotiated with industry people very seriously yet. A figure which has been discussed is $3{,}2.10^{11}$yen. It does not include escalation and contingency.

Mr. Vautrey: On page 5 you talk about 19 control rods. What are the 6 back up rods?. Does that mean that this is a completely different system from the others?.

Dr. Tomabechi: Back up system means the secondary shut-down system.

Mr. Vautrey: Are these systems completely different in design?.

Dr. Tomabechi: Yes, I think the design of the secondary shut-down system is greatly different from the others and we believe we can claim this is a completely different system for the shut-down of the reactor. In other words, we can claim the diversity of the shut-down systems.

Dr. Kessler: On the last page you are reporting about the development of ultrasonic sodium flowmeters. What is the reason for this development. Is it because they are simpler, smaller and cheaper than a magnetic type of flowmeter?.

Dr. Tomabechi: Yes, it is a very simple device and easily installed and we don't need big electric power for operation. So if we could develop this device I think it would help very much. A problem will be reliability of this ultrasonic instrument.

DISCUSSION
of Dr. Yevick's presentation

Dr. Smith: Dr. Yevick, you gave us a programme on what is going to happen in the future, but during the last year the R&D programme has been going on. Are there any highlights in terms of results which have come out during this last period about which you can tell us?.

Dr. Yevick: With respect to the SLSF safety programme the P-3 test has been concluded but the plans for the future are such that only one SLSF shot per year will be conducted. With respect to the inducer pump, this work has been completed and it looks very satisfactory. The tests will give the U.S. an opportunity to determine if an inducer type pump in the primary system will be worthwhile.

The U.S. has completed the design and construction of a 14000 gpm electromagnetic pump and has mothballed the pump.

The progress on the helical and on the straight tube double wall steam generators has been such that the test dates that I have indicated should be met but the 70 MW models have not been started as yet. The design of full scale units is to be completed before proceeding with the 70 MW model designs.

There has been a successful series of three to four big "bang" tests in the Sodium-Water Reaction Facility at LMEC [Note: LMEC (Liquid Metal Engineering Center) has been changed to ETEC (Energy Technology Engineering Center) effective 5/3/78] and surprisingly the turnaround times are low. This facility utilizes dynamic water flow and high sodium temperatures. Materials testing has been accelerated. The centre for such testing is at ORNL. Tests and calculations have provided sufficient data to give the U.S. confidence to continue to use $2\frac{1}{4}$Cr-1Mo SS for steam generators. The FFTF is about 90% completed: sodium fill will be in August 1978, criticality 1979 and full power operation in 1980. Cores 1 thru 4 have been delivered. The fuel storage facility of the FFTF will have ability to contain five years' production of FFTF spent fuel. EBR-II has been operating quite successfully, achieving plant capacity factors of 76% in 1977. Joint safety programmes with the UK are being negotiated. Discussions have been held with France and West Germany on joint safety programmes. With regard to the PLBR studies, three manufacturers in partnership with three architects and engineers had been responsible for this work under the Department of Energy and EPRI. After a total expenditure of about $18 million on the three studies the Department of Energy made a decision to discontinue support and the EPRI alone has the three reactor manufacturers looking at variations of LMFBR pool type designs. The results of the prototype large breeder reactor work were presented at the BNES Conference on Optimisation of Sodium-Cooled Fast Reactors, including the saturated steam cycle which General Electric feels has many possibilities.

Dr. Däunert: Have you any idea at the time being how your time schedule would be considering the consturction of this larger breeder reactor in your country?. You told us a lot of data for tests of components. Is it too early to ask you when at the earliest the construction of such a reactor could start?.

Dr. Yevick: The present problem is associated with a propostion made by the Department of Energy to Congress as a possible compromise and alternative to the CRBRP: to start a conceptual evaluation of a larger LMFBR with proliferation resistant fuel cycle to start now and be completed by 1981. If a decision were to be made in 1981 to proceed with the larger plant, it could not be completed before the 1990's. If the CRBRP were to continue, it could not be completed by 1986. Large numbers of CRBRP components have been ordered, for example, the reactor vessel is nearly complete, but site construction has not been started.

Dr. Smith: You commented on the licensing for the CRBR. Am I correct in assuming that the licensing process has come to a full stop even if the reactor has not?. I would also like to ask whether there have been any thoughts in the USA along the lines of the question I asked Mr. Vautrey the other day, that is to say if in any event of restarting licensing how would you intend to deal with whole core accidents and the containment argument?. And I think somebody mentioned, maybe Dr. Kessler, that he considered there was no problem now with sub-assembly accidents. One could show they did not go to whole core accidents. Is that supported in the States?.

Dr. Yevick: The licensing has been stopped for some time. The problem of containment has essentially been resolved. I don't think the problem of a core-catcher has been fully resolved and it would be an issue when licensing procedures would be resumed. A large space has been provided under the reactor for a core-catcher.

Prof. Pierantoni: Dr. Yevick, when you referred to 4 million tons of U_3O_8 did you say that the maximum foreseen price is up to $50 per pound?.

Dr. Yevick: Yes, it is up to $50 per pound of U_3O_8.

Prof. Pierantoni: Is this 4 million tons of U_3O_8 in the USA or all around the world?.

Dr. Yevick: The 4 million tons of U_3O_8 are official estimates for resources indigenous to the U.S. There are differing estimates lower than this number.

Dr. Kessler: You mentioned that the SAREF programme could be reinstated. Are there already definite plans?.

Dr. Yevick: The reinstatement of SAREF under the CRBRP compromise is a possibility.

Prof. Pierantoni: Do you have any R&D activity carried on in the United States about the extraction of uranium from the sea?.

Dr. Yevick: As far as I know, none.

Dr. Smith: Could you make any comments about thoughts on gas-cooled fast reactors in the United States?.

Dr. Yevick: There are some thoughts that the gas-cooled fast breeder has less proliferation resistance than other breeders because it has a higher internal conversion ratio approaching one with a resultant lower through-put of fuel. The U.S. has a larger effort on a gas-cooled fast breeder than in the past. A.U.S. Helium Breeder Association has been formed which is taking a very active part in the development of the gas-cooled fast breeder.

DISCUSSION
of Dr. Smith's presentation

Dr. Tomabechi: Would you please give us some information about dates of your CDFR - for instance, when do you expect to start its construction?.

Dr. Smith: Everything so far for determining dates at the moment is really dependent on Government decisions and they have said that there will be a public enquiry before this. This means, just doing simple arithmetic, it is likely to be 1983 at least, before the CDFR could be started. But I think the safest thing to say at the moment is there is no Government decision and we hopefully next year shall be able to answer your question.

Dr. Kessler: In reporting about your CDFR design you mentioned that you would have a new core-restrain system, a passive one. Could you elaborate a little more on that?. Is it just an outer ring?.

Dr. Smith: It is just a strong outer ring with two support planes above the core, one just above the level of the core, the other near the top. By passive we do mean it is a strong outer ring against which the sub-assemblies can expand.

Dr. Kessler: You mentioned that you might decrease the temperature rise across the core a little. How much would you consider is necessary?.

Dr. Smith: This is a current fashionable discussion topic. I don't think one should attach too much attention to this suggestion of reducing it by 20 or 30 degrees. A number of problems are avoided but of course the economics of the reactor is not improved. All I can say is this is just the latest thing which is being studied. Most probably it would not be adopted.

Dr. Yevick: Can you say something about your advanced fuels programme?. Are you doing any work on carbides at the present time or planting any sub-assemblies in PFR?.

Dr. Smith: I can't remember the details of the carbide programme in PFR but carbide is continued as our only advanced fuel but it is at a very low priority. There have been experiments in DFR, some of which have been analyzed and some of which, I think are awaiting analysis. So, I am sorry I can't give you a precise answer but the work goes on at the very low priority.

Dr. Yevick: Has a construction cost estimate been made on CDFR at the present time?.

Dr. Smith: No construction cost estimate has been completed at the present time. The cost estimates are in the process of being made and little is known except that they are tending to come out high. The cost estimates will be made by NPC and they have not yet released any such estimates. I can't give you any more information.

Dr. Kessler: Again, on the CDFR design you mentioned the so-called buttress system to reinforce the vessel cover. How does it look like and how much in additional strength would you gain against an HCDA or did I misunderstand this?.

Dr. Smith: This is another instance of the designers putting in the latest ideas which they have. I have not actually seen a drawing of this latest arrangement. It would have some sort of ledge or buttress which restrains the rotating shield. There is such a design in PFR in fact. I don't think the designers know, and I certainly don't know, how much stronger it would in fact be. I have some doubts myself whether it would turn out to be practicable.

Dr. Kessler: In connection with the experiments on vessel models and energy release, you mentioned that one test has been performed with a scaled energy release of 2.5GJ. You did mention that this test which has not yet been fully analyzed looks promising. What do you mean by promising?. Would the CDFR vessel withstand such a high mechanical energy?.

Dr. Smith: The model withstood that energy, that energy scaled to CDFR size. The problem is that the model is not an accurate model of the CDFR and in particular I think the roof of that model did not model the plug on the CDFR. From the other tests mentioned at the end of 10.5, we are very confident that our prestressed concrete vessel would stand explosive levels at least above 3GJ. But we are not at all confident that we could not keep the plug into the vessel at those levels. That is why we are interested in improving the hold down of the plug. I think the main vessel is much stronger than the plug.

Prof. Pierantoni: Dr. Smith, what do you mean by your expression that your transport flask is proof against terroists?.

Dr. Smith: That means if you go around and collect ten of your friends and spend a lot of time infiltrating plants to learn about the flask core structure and you provide the most modern explosive and anything else you wish, you still cannot get the fuel out of the flask in a reasonable period of time before reinforcements arrive to stop your doing so. Such a design would be in place of the suggestion for irradiating fresh fuel to make it terroist proof. We believe that we can build a flask which is first of all too heavy to take away intact because it weighs a hundred tons. You cannot take that size flask with any vehicle at more than a few miles an hour. Furthermore we would aim to transport it to and from the reactor site by rail which means there would be only a few places it could be got onto the road in any case. So then we have to design the flask so that people cannot get the material out for several hours using any sort of tools or explosives. We believe we can do that.

I did not mean to imply that you, Professor Pierantoni, were likely to be the terrorist leader but I did imply that we do assume that the terrorists are highly technically skilled people who know all details of the flask: nevertheless we still think that we can design the flask so that they could not open it. It is quite easy to design a flask so that unskilled terrorists could never open it.

Dr. Tomabechi: If I remember correctly, last year you reported to the meeting of this group that you have been considering reducing the thickness of wrapper tube. Would you please tell us the results of your study?.

Dr. Smith: I think that the thickness of the wrapper tube in the reference fuel has not been changed from the previous one. It is a balance between the dilation of the wrapper, the swelling of the wrapper due to pressure creep and until we have got more data we are not able to make that optimization perfectly.

Dr. Kessler: You mentioned for the CDFR design the so-called tertiary shut-down system using lithium 6 or tantalum balls injected into the core. How many of those, let me call them channels or sub-assembly positions, would you use to shut the reactor down?.

Dr. Smith: I cannot answer that question precisely. The reference design at the moment only has two types of shut-down systems, so called normal ones and the alternative shut-down systems. The alternative shut-down systems are the same type of absorbers, boron rods held in by sodium pressure and when the sodium pressure is lost they drop in. The other devices are only just being studied and since we don't have a precise design we don't have a precise amount of reactivity that they could control. But we would envisage that if we adopted them and it is at present unlikely that we would, there might be something like five.

Dr. Kessler: The other question relates to the cesium trapping system. Your people are using some kind of Reticulated Vitreous Carbon (RVC). Is it a hot trapping method?.

Dr. Smith: I believe it is a hot trapping method but I am not an expert in this area and I would have to ask especially. I think if you wrote and asked this I probably could tell you.

DISCUSSION
of Prof. Pierantoni's presentation

Dr. Kessler: At the beginning you said that your budget in 1977 was $41{,}2 \cdot 10^9$ lire without the expenses for the Super-Phenix.

Prof. Pierantoni: Yes.

Dr. Kessler: Then my next question is what part of the total components for Super-Phenix is the Italian industry delivery?.

Prof. Pierantoni: I think that the Italian industry supplies about one-third of the Super-Phenix components.

Dr. Kessler: Which type of components?. Pumps, IHXS and steam generators?.

Prof. Pierantoni: A lot of things are coming from the Italian industry, even the turbine, I think.

Dr. Smith: In your safety applications you have explained your difficulty in knowing exactly what you have to include in the safety documents. Do you have indications from the safety assessors what sort of standards they are asking?. Are they just saying as safe as possible or are they asking for some lines of assurance or are they asking for a particular probability of an accident or a particular risk?. What are they asking?.

Prof. Pierantoni: I think their attitude is different in relation to different professional people involved in the discussion. Usually they are trying to use "as low as reasonable concept" which means a lot of different things depending on who is applying to the concept. The situation for fast reactors is really bad in Italy due to the fact that for light water reactors they reached an agreement by which it is possible to make a reference to the plant which is already in operation. If we are building in Italy a plant which is already in operation in one of the countries or even in Italy the safety analysis is carried on only for components which are specific to the site or for components which are different from the components put into the reference plant. But for the reactor like PEC we don't have any reference reactor so we have to convince beyond any reasonable doubt that the reactor is safe. This means a lot of work, especially from the bureaucratic point of view. Now in Italy we are following the quality assurance programme like the programme being used in the US and the biggest trouble which we are finding is on documents storage. We have very severe pressure for documents storage and we have to put a lot of signatures on drawings, up to 10 sometimes. I think Dr. Yevick knows very well the problem.

Dr. Yevick: Based on the delivery of these components that you have discussed here what is your present estimated date for criticality for PEC?.

Prof. Pierantoni: We have no idea at all due to the fact that during the last years we had a lot of delays due to the approval by the Safety Commission which were about impossible to foresee at the beginning. So now we are working on the three month basis and this is all we are able to do. We are really in trouble because the site work is going on and in two or three months we will be in a lot of difficulty if we are not able to get the approval of the next group of the Safety Detailed Designs.

Dr. Smith: When you say these approvals are closely tied with construction schedules does this mean that even if you can convince the authorities you cannot go ahead?. You have to wait until you reach a certain stage before you could apply?.

Prof. Pierantoni: It is forbidden by law in Italy to build a component to be put in the reactor before Safety Detailed Design is approved. The engineers involved in this could be put in jail if the component is manufactured before the Safety Detailed Design is approved. But for PEC we are quite lucky due to the fact that this is a prototype. It is very difficult to demonstrate in a trial that a component was made for the reactor and not for R&D work.

Dr. Yevick: You indicated that three of the system safety reports have been approved by the CNEN Regulating Committee. After the CNEN Regulating Committee approves the reports what do they do with these reports?. What is your worry?.

Prof. Pierantoni: You are right. I was using the word of the CNEN Safety Division. In fact the Safety Detailed Design should be approved by a large commission made up by representatives of a lot of different Ministries - Safety, Labour, Police, Agriculture, Public Works and so on. In this Commission we have about 15 people and we should have to get the approval of this commission which is called Technical Commission for the Safety of Nuclear Plants. But before reaching such a commission we have to go through the CNEN Safety Division who act as a Public Ministry. In a trial there is a man who prepares the trial and decides whether it is necessary to go to court. This work is done by the CNEN. So usually we are getting most of our difficulties before reaching the Commission. This is the reason why I was referring to the CNEN Safety Division. We usually did not reach the opportunity to go to the Safety Commission because the report is not written well, there is something which has still to be done and so on. So the work is always done before the possibility to discuss directly with the official commission. When the report reaches the Commission we are usually sure to get the approval. The CNEN Safety Division is not in the frame of the CNEN organization. It is just a group of people who refer directly to the CNEN President and not to the CNEN General Manager.

Dr. Smith: Could you say any more about your Esmeralda sodium fire programme?. When will you start and what size fires are you thinking of testing?.

Prof. Pierantoni: We are discussing with the French CEA to join the Esmeralda programme. As you know, during the last three or four years we made some experiments in Brasimone on SATANA and SARACINO. But we are now joining on Esmeralda experiments with France. On the other hand in Brasimone we have now built the rigs for the rotating part of the pump testing in the place where we made the first experiments on sodium fires.

Dr. Yevick: What is your present cost estimate for PEC?.

Prof. Pierantoni: Our present cost estimate is about 200 billion lire. But part of the cost is referring to money which we spent two or three years ago. So I think that if we have to take into account escalation, replacement cost will be about 300 billion lire probably.