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海外出張報告

(1)第22回OECD・NEA・CRP
(2)フランス高速炉関係施設訪問
(3)「高速増殖炉とヨーロッパ」国際会議

昭和54年11月

動力炉・核燃料開発事業団

この資料は動燃事業団の開発業務を進めるため限られた関係者だけに配布

〒319-1184　茨城県那珂郡東海村大字村松4番地49
核燃料サイクル開発機構
技術展開部　技術協力課

海　外　出　張　報　告

(1)　第２２回 OECD・NEA・CRP
(2)　フランス高速炉関係施設訪問
(3)　「高速増殖炉とヨーロッパ」国際会議

要　　旨

OECD・NEA・CRP（Committee on Reactor Physics）の第２２回目の会合がパリＯＥＣＤ本部で開催された。各国から２３名の関係者が出席し，軽水炉および高速炉に関する炉物理分野のトピックスについて議論を行った。今回から，炉心回りの話題の他に，臨界安全などの燃料サイクルの話題も加わったため，活動範囲がより多岐にわたることとなった。

続いて，フランス国内のキャダラッシュ研究所，スーパー・フェニックス建設現場，ノーバトム本社，ＣＥＡ本部などを訪問し，高速炉炉心設計，安全評価の考え方などの現況について討論を行った。

最後に，スイス原子力関係機関（SVA−FORATOM）主催の「増殖炉とヨーロッパ」と題する国際会議に出席し，「我が国における LMFBR 開発の現況」について発表した。

昭和５４年１１月

高速増殖炉開発本部
井　上　晃　次

日　　程

月　日　曜日	場　　所	訪　　問　　先
9月29日　土	東京	（移　動　日）
30日　日	→ パリ	（移　動　日）
10月　1日　月	パリ	第22回OECD・NEA 炉物理委員会（CRP）に出席（OECD本部）
2日　火		
3日　水		
4日　木		
5日　金		
6日　土	パリ	
7日　日	パリ→エキサンプロバンス	（移　動　日）
8日　月		キャダラッシュ研究所
9日　火	エキサンプロバンス→クレイマルビイユ	（移　動　日）
10日　水		スーパー・フェニックス建設現地
11日　木	クレイマルビイユ→パリ	（移　動　日）　CEA本部
12日　金		NOVATOME社
13日　土	パリ→ルチエルン	（移　動　日）
14日　日	ルチエルン	
15日　月		SVA-FORATOM国際会議に出席
16日　火		
17日　水	ルチエルン→チューリッヒ	
18日　木	チューリッヒ	（移　動　日）
19日　金	→ 東京	（移　動　日）

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1. 第２２回OECD・NEA・CRP（OECD・NEA炉物理委員会）

1.1 出張報告

1) 場　所 ：ＯＥＣＤ本部

2) 出席者 ：米（３），日（２），英（２），仏（２），独，ベルギー，加，スペイン，フィンランド，伊，スイス，ユーラトム，ＮＰＣ（以上各１），ＮＥＡ（３），IAEAオブザーバー（ソ連２），（Barré，Farinelli，Richmondが去り，新しい人と交代した。）

3) 期　間 ：１０月１日（月）～１０月５日（金）

4) 議　事 ：（1.2の Agenda に従って次の通り議事が進められた。）

(1) Part A Executive Sessions

① 第２１回議事録確認，Agenda の採用，前回の Actions の現況

② 第２１回NEA・NDCへのオブザーバー報告（Debrue 氏）

- High priority nuclear data request list

  prority 1 について米，日が英独仏より多すぎる理由について議論あり，再チェックしてしぼることになった。

- Availability of ENDF／BV

  米国としては従来の完全公開をさしひかえるとの発言，理由はまだ完全に完了していないこと，comparison と improvement の作業には exchangeするものが必要

- 核データ関係の meeting

  ヨーロッパ，米，ソ連でそれぞれ３年毎に大きな会合を開いており，実質的には年１回，多すぎる，CRPとして recommendation を出すことにした。

③ NEA CRP 関係文献の配布

L（公開）とA（限定）にして部数減の方向に改善

④ Report on the renewal of the mandate of NEA CRP

NEAのステアリング コミッティーで採択された。member の数は限定して欲しいとの要望あり。

⑤ NEA Data Bank の活動

Saclay 移転以降大体順調に動きだした（日本からも専門家３名参加）。来春米国にて Code 情報交換の会議がある。

(2) Part B Technical Sessions

① Transactinide Nuclear Data, IAEA/NEANDC Cadarache May 1979, Bouchard 説明, 来年月に report が出る。

② Int. Symp. on Fast Reactor Physics, Aix en Provence, Sept. 1979, 仏, 独, 英などから感想あり。

Küsters 発言, 東京 Symp では conclusion がはっきりした。Aix では余りはっきりしない。hetero. core は他の熱流力, 安全も含めるべきだ。

③ SMORN Ⅲ, Oct. 1981, Tokyo 弘田氏説明

欧州, 米国などの corresponding members, Benchmark で議論あり。

④ SM on Calculation of 3-D rating distributions in operating reactors. Paris, Nov, 26-89, 1979

Askew 説明。日本からも2名参加の予定

⑤ In core measurement (≃ Interpretation in reactor measurement) NEA CRP が organize するか, IAEA の共催とするか追って検討(Bouchard 提案か)

⑥ Blankets: neutron deep penetration problems

英, 日, 米(2)が口頭, 米(1) paper.

問題は, blanket 中 U238 核分裂率の計算, blanket 中の gamma 加熱と blanket-shield interface の計算, reactivity-control monitors の位置, 遮蔽計算初期 flux の予測, 代替遮蔽材の研究, に分けられる。

輸送計算又は輸送補正計算で±3%(1σ)位で U 238 fission rate は予測可能。しかし, より単純な計算で精度を上げることも必要(modified diff), gamma 加熱の予測精度はまだ悪い。graphite & borated graphite 研究必要。

⑦ Shielding: 英(3), ユーラトム(1)

1973年NEAで計画がたてられて以降, shielding benchmark は6件実施され完了した。これ迄の活動を review する意味で SM on Sensitivity and Uncertainty analysis, Shielding benchmark experiments の提案があり, 来年末頃開くことにした。Rief が音頭とり, 日本からは安先生を corresponding member に推せん。

⑧ Isotopic correlations for fuel exposure history determinations,

独（２），仏（１），日（２），ユーラトム（１），米（１），ベルギー（２）

spent fuel の chemical analysis 又は関連アイソトープ比（Pu／U，Cs 134／Cs 137，他のアクチナイドやFPの比）の burn-up 依存性などの技術が使用されている。その linearity の問題，check する意味での相互技術の採用，再処理での Pu content の決定，safeguards との関連の重要性など議論あり，今後も継続検討。独（A366）と仏（L234）の papers がよくまとまっている。

⑨ Power peaking，日（１），仏（１），英（１）

In-core instrumentation についてSM をもってはどうかの議論あり。

⑩ Detailed review of conclusions from the LMFBR Benchmark，ANL 1978，Le Sade によってまとめられた Proceeding 概要説明，問題は radial fission rate dis と control rod worth 予測，各国で見解まちまち。１１月末迄に draft に comments をすることになった。

⑪ Summary of Hydrogen entry benchmark

今年中に comment，KFK ではこの仕事は stop する。

⑫ Mult-dimensional kinetics benchmark

近いうちに Kusters が specification をはっきりさせる。目的はできる限り限定する。

⑬ SMORN—Ⅲ との関連 noise analysis benchmark の提案（弘田氏）。specification づくりで多数意見があり，炉心からの情報にもとづく方は沢山の情報，長い期間が必要となり消極的，model を linearized した単純なもので行うべきとの意見多数。

⑭ Miscellaneous topics ソ（２）

70001 core の critical experiment
Actinide Build-up cal
} の紹介

⑮ Heterogeneous cores，including safety related FBR problems，英（１），スイス（１），日（１），仏（１）

Campbell 氏より Aix 会議のまとめを説明，Hetero の目的は void coeff と radiation dammage の減少にある。多くの実験が行われた。日本，米国，BIZETなど。BIZET以外は smaller size，全体の印象として，もし大きな Na void 減少を望むなら炉心中心に大きな blanket 領域をつくる。design

studies も沢山出た。$ 1.5程度は可能らしいという印象。日本の説明は安全解析に関連する問題，TOPとLUCとを対象，void coeff の大小により kinetic energy release に大差なし。但し，予備的結論と説明。仏，独が大きな関心を示し；同様の解析を行っているとのこと。

⑯ Fuel cycles，仏(2)，ベルギー(1)，加(1)，フインランド(1)

高速炉における reshuffling (仏)，Th系と Pu系の炉心特性の比較(仏)，long term uranium demand and supply in CANADA，BWRの BU 上昇のための studies，8×8 → 9×9 に改造(フインランド)など。

⑰ National Programmes，各国 activities 概要説明，日本の説明に対して，英，独より energy release rate の実験 data 送って欲しい旨，要望があった。

⑱ Progress with the NEA CRP Book on the Status of Fast Reactor Physics

第1章(clean core)，独，draft 未完成

第2章(burn up)　，仏，　〃　未完成

△第3章(control rod)，英，draft が配布された。…→今年中にコメント

○第4章(blanket)　，日，完成，最終版を通知した。

○第5章(shielding)，伊，完成

△第6章(safety)　，米，書き直し中

今後のスケジュール，80年1月末迄に draft を送り，約半年で comments を出す。

⑲ Criticality problems in storage and transportation in out-of-pile fuel，仏(2)，日(1)，ベルギー(1)，米(2)

形状が複雑で，実験データも少ない分野である。特に未臨界度の大きい体系の予測は難しい。0.5%での精度予測は現状では難しいが，今後の努力により達成可能であろう。

(3) 次回のNEACRP

① Topics carried over

イ Heterogeneous cores

ロ Neutron penetration problems

ハ In-core instrumentation

ニ Criticality problems in "out-of-pile" fuel storage and transport

ホ LMFBR benchmark（Hammer より hetero の propose あり）

② New topics

ヘ Structural materials, reactivity and activation

ト Pressurized transient studies

チ Problems in the interpretation and analysis of critical experiments

リ Methods of utilization of information from operating reactors

５５年９月２２日（日）～９月２６日（金），米国 Idaho にて

（前の週９／１４～２０ ANS主催 Aduances of Reactor Physics, LMFBR & LWR の会議あり）

1.2 Agenda

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

NUCLEAR ENERGY AGENCY

SEN/NEACRP/A(79)2

RESTRICTED

Paris, 16th July 1979

Or. Engl.

NOTIFICATION OF MEETING

STEERING COMMITTEE FOR NUCLEAR ENERGY

Twenty-Second Meeting of the
NEA COMMITTEE ON REACTOR PHYSICS

As agreed at the 21st Meeting, the 22nd Meeting of the NEA Committee on Reactor Physics will be held at OECD Headquarters, Château de la Muette, 2 rue André Pascal, Paris 16, from 1st to 5th October 1979.

After consultation with the Chairman of the Committee, the following provisional agenda is proposed :

Part A : Executive Sessions

1. a. Participants in the Meeting
   b. Committee membership
2. Adoption of the Summary Record of the 21st Meeting
3. Adoption of the agenda of the Meeting
4. Completion of actions arising from previous meetings
5. Activities of other bodies of interest to NEACRP
6. Report of the NEACRP observer on the 21st Meeting of NEANDC
7. Distribution of NEACRP documents
8. Report on the renewal of the mandate of NEACRP
9. Report of Working Group discussions on NEA Data Bank activities in computer program exchange
10. Arrangements for the 23rd Meeting of the Committee
11. Other business
12. Election of Committee officers

Part B : Technical Sessions

1. New Topics

   1.1 Isotopic correlations for fuel exposure history determinations

   1.2 Criticality problems in storage and transportation in 'out of pile' fuel

   1.3 Blankets : neutron deep penetration problems

   1.4 Miscellaneous topics

2. Topics carried over from previous meetings

   2.1 Heterogeneous cores, including safety related FBR problems

   2.2 Power peaking

   2.3 Fuel cycles

3. National Programmes

   Review of recent activities and national programmes

4. Benchmarks

   4.1 Detailed review of conclusions from the LMFBR Benchmark, Argonne National Laboratory, 1978

   4.2 Summary of Hydrogen entry benchmark

   4.3 Specification of multi-dimensional kinetics benchmark

   4.4 Proposal for noise analysis benchmark in connection with SMORN III

5. General

   5.1 Highlights of recent meetings of interest to NEACRP

   - Specialists' Meeting on Homogenisation Studies, Lugano, Switzerland 1978
   - International Symposium on Fast Reactor Physics, Aix en Provence, September 1979
   - NEANDC Specialists' Meeting on the cross sections of the Heavier Plutonium Isotopes and Americium Isotopes, Brookhaven National Laboratory, USA. November 1978
   - Transactinide Nuclear Data, IAEA/NEANDC Cadarache, May 1979

5.2 Specialists' meetings planned or proposed

- 3rd Specialists' Meeting on Reactor Noise (SMORN III) October 1981, Tokyo
- Specialists' Meeting on Calculation of 3-dimensional rating distributions in operating reactors. Paris, November 26-28 1979
- NEANDC Specialists' Meeting on the Cross Sections of Fission Product Nuclei, Bologna, Italy. December 12-14 1979
- NEANDC Specialists' Meeting on the Capture Cross Sections of Important Fissile and Fertile Isotopes, Argonne National Laboratory, USA. 1980
- IAEA/ENS Topical Meeting on Numerical Methods, 1981

5.3 Progress with the NEACRP Bock on the Status of Fast Reactor Physics

Hotel Accommodation

Participants are asked to contact Dr. P.D. Johnston, NEACRP Secretariat, OECD Nuclear Energy Agency, 38 Boulevard Suchet, Paris 16, as soon as possible. (Telex 630668 AEN NEA)

1.3 配 布 資 料

1. Isotopic correlations for fuel exposure history determinations

A-365 Experimental evidence of isopic correlations
L. Koch

A-366 Isotopic correlation techniques - A review.
H. Küsters/M. marzo

L-234 Etudes de correlations isotopiques pour des applications aux fontionnements des reacteurs et des usines de retraitement. M. Darrouzet, A. Giacometti

L-232 Determination of Pu accumulated in irradiated fuels by non-destructive isotopic correlation technique
H. Tsuruta, T. Suzaki, S. Matsuura

A-386 Isotopic correlations in irradiated nuclear fuels.
C. Foggi Euratom Ispra

A-377 Isotope correlations and measurements in the U.S.
P.J. Persiani

A-371 Requirements for fission-product nuclear data related with reactor fuel characterization.
L. Leenders, et al

A-372 "Burnothèque" A valuable standard for accurate burn-up determination by non-destructive examination.
H. Adachi, J. Basselier, L. Leenders

A-358 Some correlations between isotopes of Nd, U, Pu and burnup parameters for the FBR irradiated fuel.
S. Nakayama et al

2. Creticality problems in storage and transportation in 'out of pile' fuel.

L-237 Criticality analysis for storage and shipping of nuclear fuel elements outside of reactors. G. Ermumcu, et al

L-236 The experimental results from CRISTO qualification fo the predicted crticality of fuel storages. C. Golinelli, et al

A-359 Criticality computation using the Monte-Carlo Code KENO-4 with a new multi-group constants library Y. Naito, et al

A-370 Calculation of the multiplication factor of a PWR spent fuel storage configuration. G. Minsart

L-240 KEMA : Calculations for compact storage racks for PWR fuel. W.J. Oosterkamp

A-391 Standardized safety analysis of nuclear fuel shipping containers. Robert M. Westfall and Leslie M. Petrie

A-390 Out-of-Pile criticality studies (US).

3. Blankets : neutron deep penetration problems

A-385 Notes on U.S. Fast Reactor Blanket and Shield interface studies.

A-376 LMFBR reactivity surveillance using ex-core detectors M.J. Lineberry, S. G. Carpenter, C.L. Beck

4. Miscellaneous tonics

A-392 Progress Report of the Dutch Nuclear Data project for fast reactors covering the period April 78/Sept. 79.

A-393 The investigation of control rod physics problems in the large power fast reactor mock-up.
U.A. Kazanskii, et al.

A-394 Nuclear data and precisions of actinide build-up calculation in fast reactors.
O.D. Bakumenko, et al.

L-241 An appraisal of the NEA Collaborative programme of uncertainty analysis and shielding benchmark experiments October 1979. J. Butler and H. Rief

A-388 Preliminary version of the EURLIB variance-covariance matrices M.C.G. Hall

A-389 Contribution to the IAEA/NEA Programme of uncertainty analyses in generic reactors - A sodium-cooled fast reactor. M.C.G. Hall

A-387 A simple comparison of adjusted data sets for iron-based on measurements in ASPIS and in the cores of fast reactor criticals. M.C.G. Hall

5. Heterogeneous cores, including safety related FBR problems

A-369 Critical experiments in a zero-power fast reactor lattice with breeder zones of thorium and uranium.
U. Schmocker, EIR, et al.

A-380 Neutronic problems related to the heterogeneous core concept safety : studies devoted to the sodium effect. JC Cabrillat, P. Hammer

A-357 A study on the potential safety advantage of heterogenous LMFBRs (I) K. Miyagi et al

6. Power peaking

L-235 Work on gamma thermomenter in CEA, A. Bonnemay et al

A-356 Power peaking and its design margin of JOYO, F. Yosino

7. Fuel cycles

L-233 Long term uranium demand and supply in Canada M.F. Duret

L-238 Neutronic characteristics of a 1200 MWe fuelled with (ThO_2 - 233 U) O_2

A-395 Benchmark experiments related to actinide production in thermal reactors : Experiments in the VENUS critical facility. De. Raedt, Leenders, Minsart, SCK/CEN, Mol.

L-239 Preliminary study of the sub-assembly reshuffling in fast breeders. JC Cabrillat

A-374 Fast reactor fuel cycle studies. Y.I. Chang, C.E. Till

8. Detailed review of conclusions from the LMFBR Benchmark, Argonne National Laboratory, 1978.

8-1 Proceedings of the NEACRP/IAEA Specialists Meeting on the International Comparison Calculation of a Large Sodium-Cooled Fast Breedor Reactor at Argonne National Laboratory on February 7-9, 1978.

A-364 Investigations related to the international comparison calculations of a large sodium-cooled fast breeder reactor. C. Broeders

A-383 Comments on the draft Proceedings of the NEACRP/IAEA Specialists Meeting on the international comparison calculation of a large sodium-cooled fast breeder reactor. M. Nakagawa

A-375 Analysis of radial fission rate distributions in ZPPR cores. P.J. Collins, ANL

9. Specification of multi-dimensional kinetics benchmark.

A-367 Kinetic Benchmark, Munich 1975. H. Küsters

10. Proposal for noise analysis benchmark in connection with SMORN III.

A-384 Proposal for the third specialists meeting on reactor noise (SMORN III) - submission to NEACRP 22nd meeting. Y. Kuroda et al

11. NEA NDC 関係

A-363 Report on the 21st Meeting of NEANDC by the NEACRP observer. J. Debrue

A-362 Statement from Dr. Chrien (NEANDC): Exchange of evaluated nuclear data files between NEA Member countries

A-360 Report to the NEA Nuclear Data Committee September 1979 Sub-committee on technical activities of the NEANDC

12. その他

A-361 Summary of NEACRP views on actinide production and burn-up. J. Hirota et al

A-379 Experimental studies of large conventional LMFBR cores at ZPPR. M.J. Lineberry, et al.

A-378 Experimental studies of 350 MW(e) Heterogeneous LMFBR cores at ZPPR. P.J. Collins, et al

12-1 ИЗУ9ЕНИЕ ХАРАКТЕРИСТИК РАЗМНОЖАIОП И УРАНОВОИ СРЕIIН СК $\infty \approx$ I

A-368 NEACRP Specialists Meeting on 3-dimensional rating distributions in operating reactors. Proposed participants at 27.9.79.

A-373 NEACRP monograph : "Current status of fast reactor physics" Reactor coefficients". Argonne National Laboratory

A-382 Définition des caracteristiques d'un milieu de référence à combustible oxyde d'uranium enerichi et A K_∞= 1 à partir des mesures realisées au CEA J. Bouchard, M. Darrouzet, L. Martin Deidier

12-2 DRAFT

CHAPTER FOR NEACRP BOOK

13 まとめ

上記提出論文をトピックス毎に国別件数でまとめると次の通りである。

トピックス＼国	フランス	日本	英国	米国	ドイツ	ベルギー	イスプラ	スイス	カナダ	ソ連
1. Isotopic correlations	1	2		1	2	2	1			
2. Criticality problems	2	1		2		2				
3. Blanket				2						
4. Heterogeneous core	1	1						1		
5. Power peaking	1	1								
6. Fuel cycles	2			1		1			1	
7. LMFBR Benchmark		1		2	1					
8. その他	1	2	4	3	1	2	1			3
9. National programmes			（各国共提出）							

1.4 各トピックスについての short summary

1. Summary of the Discussion on Isotopic Correlations (8 papers)

The topic has been discussed for the first time on NEACRP. The technique is used frequently in the chemical analysis of spent fuel and it relates istopic ratios (concentrations, activities) as Pu/U, Cs134/Cs137 or other ratios of actinides and fission products with burn-up (or depletion) or to each other. Much experimental evidence is available ; some of these correlations are linear over a wide range of burn-up, but it has to be stated clearly that there is no physical reason for linearity. The assumption of linearity can lead to erroneous conclusions, especially if linearity is used for interpolation and extrapolation of experimental results.

The field of application can be manifold :

1. Consistency checks of analytical data obtained by isotope dilution techniques on active feed solution samples from the reprocessing plant.
2. Independent checks on burn-up determination.
3. Determination of the Pu content in the dissolution process.
4. Dynamic inventory determination in a reprocessing plant.
5. Non-destructive determination of Pu content and burn-up spent fuel.
6. Verification of the analytical data by safeguards inspectors.
7. Check and location of fuel failures by means of fission product monitoring.

The most important application of isotopic correlation might be in the field of safeguards. The present uncertainty of chemical and physical measurements on the content of fissile material in spent fuel is about 1% and it is unlikely that it can be improved much further to an accuracy which would be needed to get a reliable detection of diverted material (less than 0.1%). It was felt that isotopic correlations cannot by themselves be a replacement of the usual measurements in safeguards applications, but that many independent correlations might narrow the uncertainty margin and that possibly systematic errors in the chemical determination of the fissile content can be eliminated.

A validation and improvement of the at present mainly empirical approach of isotopic correlations can be based only on a thorough check of reactor physics calculations with experiments and a complete understanding of the sensitivity of the correlations to possible influences from the in-pile performance and out-of-pile conditions of reactor fuel. The special purpose of application is important in these sensitivity studies. It was felt that the theoretical exploration of the isotopic correlation technique at present has not gone so far as to resolve the various conditions

for a reliable application for various purposes. A reliable uncertainty margin of the various measurements is strongly required.

As an ultimate aim it is to be discovered what type of correlations are insensitive to local in-pile effects, and what type is even insensitive to reactor types (e.g. BWR, PWR). It has to be validated what approximation to a rigorous reactor physics calculation is adequate for the various application areas in order to have a fast and sufficiently accurate theoretical method to make the isotopic correlation technique a valuable tool in fuel cycle analysis.

The Committee expressed the opinion that this topic should be followed up and further results brought forward at the next meeting.

(H. Küsters)
5.10.79

2. Criticality problems in fuel storage and transportation (7 papers)

The subject spans a wide variety of activities in out-of-pile fuel studies, a common feature being the interest in validation - and possibly standardization - of relatively simple methods for the calculations of fuel arrays and solutions. A large number of soundly based guidelines for criticality safety limits and controls is available in the open literature, as indicated in a short U.S. paper.

Safety-oriented criticality calculations of heterogeneous systems were contributed by Belgium, France and Japan: these studies are encouraged and supported by utilities, in view of the economic incentive related to the optimization of the fuel quantities that can be stored in a single pool.

The performances of diffusion, transport and broad-group, few-history Monte Carlo codes have been intercompared and compared with experiments and "exact" Monte Carlo solutions. No large discrepancies have been observed in the results yielded by different approximate methods. Still, the treatment of strong heterogeneities or complicated geometries is a problem in standard methods, and the group-Monte Carlo approach is much favoured in some countries. KENO IV is of particularly wide usage.

Critical experiments with test regions of $K_\infty \simeq 1$ have been carried out in France and others are planned in the near future; typical experimental accuries of 0.5% in K_∞ - with some possibilities of reducing them by a factor of 2, were quoted. Comparisons with calculations could be made on the basis of simpler subcritical measurements, but it was agreed that critical experiments are more suitable to supply additional information in the code valid tion phase.

C/E values for heterogeneous arrays are difficult to assess at present: very few "ad-hoc" experiments are available, and the optimization of adequate calculational schemes is still in progress. It was suggested, however, that accuracies of about 0.5% should be well within reach. The implementation at Oak Ridge of the modular system SCALE for criticality and shielding calculations of shipping containers, was reported by the U.S. It is anticipated that NRC will make it available on request. Need for standardization in this area was recognized, and SCALE is a significant step in this direction. The addition of heat transfer and structural integrity modules - which is planned - would provide a reference integrated package able to handle any problem envisageable in fuel transportation..

3. Blankets : Neutron deep-penetration problems

This subject includes a number of related but separate topics. These include

a) calculation of U.238 fission rates through the blanket;

b) calculation of gamma-ray heat generation through the blanket and blanket-shield interface;

c) location of reactivity - control monitors;

d) prediction of starting fluxes for shielding calculations: and

e) study of ~~ultimate~~ alternative shielding materials.

It was generally agreed that transport calculations ~~on~~ or transport-corrected calculations can give adequate accuracy for U.238 fission rates, with a value of ± 3% (1σ) suggested by Campbell for MOZART or BIZET assemblies using S4 or S8. There remains a desire for simpler methods of calculation and the use of a modified diffusion coefficient is pursued in France. Gamma-ray heating is handled less well and further study is required.

The response of remotely-located reactivity monitors depends strongly upon control-rod positions, etc. However, it was observed widely that results from the modified source-multiplication technique can be interpreted adequately using diffusion theory even to shutdown levels of the order of 25 ¢ subcritical.

For deep penetration of neutrons into shielding materials, the source term may be obtained from diffusion theory or from the discrete-ordinates calculations used to predict the attenuation. Interest was expressed in examining alternative shielding materials, especially graphite and borated graphite. The reduced shield weight could greatly impact reactor seismic problems.

Measurement programs continue in several countries and further results may be anticipated. Therefore, the Committee will retain this subject for a future meeting with the time of the next discussion to be determined.

4. Summary of shielding

In this session G. Campbell from Winfrith presented three papers by M.C.G. Hall on a "Preliminary version of the EURLIB Variance-co-variance Matrices", on "A simple comparison of adjusted data sets for iron based measurements in ASPIS and in the case of fast reactor criticals" and on "Uncertainty analysis in a typical sodium-cooled fast reactor".

These papers dealing with uncertainty analysis and data adjustment in iron and sodium deep penetration problems were followed by a status report on the NEA collaborative program on the same item ("The NEA collaborative programme of uncertainty analysis and shielding benchmark experiments") compiled by J. Butler and presented by H. Rief.

It could be shown that substantial progress in achieving the objectives identified by the 1973 NEACRP could be made. In particular, 6 shielding benchmarks were performed or were close to completion, new methods for multidimensional sensitivity analysis and for data adjustment applicable to large numbers of energy groups and simultaneously to several experiments have been developed and tested. Unfortunately, the compilation of a new data request list for shielding is hampered by the lack of uncertainty assignments for the available data files.

In an attempt to overcome these difficulties, M.C.G. Hall constructed out of the ORNL 15 group covariance matrix by poly-nominal interpolations in a "background" approach a coarse variance-covariance matrix for the 100 group EURLIB structure. With this he could meet the target accuracy for certain iron quantities in the analysis of a generic sodium cooled FBR design. He also obtained promising results in a data adjustment calculation of ASPIS.

On the basis of these recent achievements, the NEACRP was asked to sponsor a specialist meeting on shielding benchmark analysis and related topics in spring 1980.

The proposal got general approval; the committee recommended, however, to confine the proposed agenda as much as possible and to hold the meeting in late 1980, to give participants more time for preparing the meeting. In a further proposal it was suggested (F. Maienschein) and agreed that participants should receive 6 months prior to the meeting detailed information on the different benchmark experiments, in particular ASPIS and EURACOS, to allow them to test their methods. It was also understood that it might be possible to obtain ENDF/B5 co-variance files for a few selected materials in the frame of this action.

The meeting will be organized in Paris by P. Hammer in collaboration with J. Butler, H. Rief, and G. Hehm, together with a Japanese and a U.S. corresponding member to be nominated by Dr. Hirota and F. Maienschein respectively.

H. Rief
4th October, 1979.

5. Heterogeneous Cores, including Safety Related Problems

1. The interest in heterogeneous fast reactor cores stems from the ability of such cores to improve the performance of fast reactors. In particular they offer the prospect of :

(i) much lower reactivity given on loss of sodium;

(ii) improved breeding characteristics;

(iii) reduced radiation damage.

2. On the other hand, the disadvantages of this type of system lie in :

(i) the reduced Doppler coefficient of reactivity;

(ii) problems relating to the thermal cycling of the above core structure due to the presence of blanket regions within the core.

3. Until the Aix meeting little experimental evidence was available to substantiate the claims for heterogeneous core performance.

4. Even now, safety studies for heterogeneous cores remain to be completed so that the overall effects of reduced sodium void reactivity on the one hand and reduced Doppler reactivity on the other remain to be evaluated. The lack of safety related results is probably due to the need to extend some of the safety codes to deal properly with the detailed description of the core with the added complication of internal breeder regions.

5. Turning to the experimental validation of cores of heterogeneous designs, there were at Aix valuable contributions from Japan, the U.K./ Debene BIZET programme in Zebra, the U.S. SPPR programme, and from the French Pre-Racine programme in Mazurca.

6. Of these programmes, only the BIZET programme had as its objective the study of the properties of reactors approaching the size of a commercial station; the other studies were of a more fundamental type or related to smaller systems. Even so the BIZET programme had not attempte to mock-up the design of heterogeneous fast reactor favoured at present by the U.K. and German design companies PNC and Interatom. Instead it had studied separately the properties of a core with

firstly - distributed islands of fertile material within a large fissile zone

and secondly - a re-arrangement of these islands to create a large central breeder zone surrounded by fissile material.

The favoured PNC and Interatom design comprises a combination of these concepts with a fairly large central breeder region. Power flattening in the simple enrichment fissile annulus is achieved by interrupted rings of fertile material or "islands".

7. The FCA programme in Japan had had as its main objective a basic physics study of the properties of a core with a central blanket zone of varying thickness from 20 cm to 40 cm, surrounded by fissile material axially and radially.

8. The U.S. contribution presented the analysis of the multiring cores characteristics of the CRBR but with more refined analytical methods.

9. In the French Pre-Racine programme, a central breeder zone had been studied with the emphasis on sodium voiding characteristics relative to those of a conventional design. A feature of the work was the influence of the Pu 240 content of the fuel on sodium voiding in the range from 8 to ~~12~~ 14%.

10. The detailed analyses of the BIZET results are not yet complete but the following general conclusions can be drawn from the heterogeneous core studies reported:

(i) Introduction of relatively thin blanket regions - such as the FCA central blanket or the "island" core of BIZET or the multirings of the ZPPR core causes the sodium voiding reactivity to increase in the blanket regions, and to decrease in the core by approximately the same amount. Thus, if such blanket regions are assumed not to lose sodium, then there is a small but useful reduction in sodium voiding reactivity brought about by their presence.

(ii) To effect a substantial reduction in sodium voiding reactivity, it is necessary to introduce a relatively large breeder region such as the large central island of the BZD BIZET core. The leakage of neutrons into this blanket region significantly enhances the negative contribution to sodium voidin reactivity.

The BIZET work had shown that if this central blanket region is too large, the annulus core becomes neutronically de-coupled and undesirably sensitive in its power distribution to small perturbations in the core, such as control rod movements or changes in material composition. For this reason a core with reduced central breeder size had also been studied in the BIZET programme which showed improved power stability, yet retained most of the desired reduced sodium voiding characteristics.

(iii) The properties of heterogeneous cores are not at this stage predicted with the same accuracy as conventional cores, and many of the analyses have pointed to the increased importance of transport corrections to diffusion solutions and the need to improve the prediction of neutron streaming from both pin and plate calls.

(iv) The Pre-Racine work has shown that the sodium voiding reactivity increases with Pu 240 content but the variation is well predicted. — using KARAVAL II data

(v) The interaction effects of control rods is significantly more pronounced in the central breeder heterogeneous design than in conventional cores, but these effects have not proved difficult to predict by diffusion theory.

(vi) Plutonium build up in the central blanket regions has only a very small effect on the sodium voiding performance.

(vii) Predictions of the gamma-ray contribution to internal breeder power in heterogeneous cores by Monte Carlo methods are in good agreement with the TLD measurements carried out in the BIZET programme.

11. At the Aix meeting, a paper describing the aims of the French Racine programme in MASURCA was presented. One of the main features of this programme is the experimental parametric study of the influence of the position and size of breeder rings on such properties as the radial power form factor and sodium voiding reactivity.

12. In the design-study papers in the following sessions of the Aix meeting, the range of objectives sought in heterogeneous designs became evident. The Interatom paper had been seeking a design with low voiding characteristics which had been achieved by the relatively large central breeder region surrounded by a fissile region with broken rings or islands of fertile material. In the U.S. work, which had been aiming at cores with less than 2½$ sodium voiding reactivity, the size of the central breeder island seemed somewhat smaller and if this were increased, then the 2½$ objective may be more easily attained.

13. Those designers whose principal interest lay in improved breeding characteristics - and these were mainly in Russian contributions - the advantages of high density fuel in the breeder regions were mentioned, such as carbide and metal. Attention was drawn to the need to minimize the fissile loading to achieve low uranium ore consumption, which may be a more useful measure of overall breeding performance.

14. The overall impression, however, was that the presently favoured designs for heterogenous cores were not very dissimilar and only varied in the size of the central breeder region and in the number and arrangement of the relatively thin surrounding breeder regions.

15. There was general agreement that there is little interest in axially heterogeneous cores of the "parfait" design.

C.G. Campbell
4th October, 1979.

6. Power Peaking - Summary

The only paper on the Agenda, Power peaking and its design margin in JOYO, was presented by Dr. Inoue. The paper included comparisons between experiment and theory. Dr. Askew drew attention to data on both channel to channel power prediction (±2% RMS) and ring to ring power as determined by PIE on AGR fuel.

Several members expressed disappointment that restrictions on publication prevented a full appreciation of the state of the art on power peaking and on associated problems - such as the question of optimal axial distribution of Gadolinia in control rods for BWR - which was known to be the subject of studies in several member countries. This was especially unfortunate because of the important role of power peaking margins in operational safety studies.

In-core measurements were a potential component of such assessments. Only one paper, Work on gammy thermometry in CEA, was presented, by Dr. Bouchard. To date, the neutron component of heating of the thermometer had not been determined. The paper showed the lag to be expected following power changes in the reactor due to the large delayed contribution to gamma flux. Dr. Askew said that self-powered detectors were being studied in the SGHWR.

In discussion, the point was made that some additional information was expected to be provided in contributions to the specialists meeting on 3-D rating distributions to be held in November 1979. The problems of relating peak pin powers to measurements in the assembly would also be discussed.

In view of this, it was proposed that the topic be raised again in the 1980 meeting to allow further time for contributions and for the results of the specialists meeting to be evaluated

The suggested specialists meeting on in-core instrumentation should therefore be postponed until 1981 so that a better appreciation of the significance of the problem, and a more precise definition of the scope of the meeting, would be possible.

J.R. Askew
4th October. 1979.

7. Fuel cycles

General fuel cycles papers were described briefly to the participants. In general, they fall into two categories, those dealing with different reactor design and operating characteristics and those dealing with reactor strategies (scenarios) using variance reactor types.

The possibility of using only a single enrichment for equilibrium operation of FBR's inward radial shuffling of fuel has been investigated by M. Cabrillat for two and three region cores. In this study it was found that this shuffling scheme cannot provide simultaneously a good power form factor and a maximum DPA lower than the present limits. However, 3 region cores provide more uniform discharge burnup distributions, better form factors and higher breeding gains than 2 region cores.

From the operation of the Venus reactor in Belgium over a period of ten years which contains a core of mixed oxide fuel, it has been possible to deduce from the reactivity changes associated with decay of Pu-241 and growth of Am-241 the half-life of Pu241 and the effective cross section of Am-241 in a typical PWR spectrum. The Japanese have made similar measurements.

The use of thorium fuel in a typical fast breeder reactor is of interest to INFCE studies. France (and many other countries) have studied this possibility. Their results in common with others show that although using thorium leads to a lower void coefficient and lower fission product absorption, the breeding gain is significantly reduced and the doubling time increased. A number of improvements can be made but the large reduction in breeding gain is most significant if the breeder is to produce fissile material.

Some management methods to reduce uranium consumption in LWR's have been investigated in Finland and it appeared feasible to expect reductions in fuel costs and mined uranium requirements of from 20-30%. This estimate appears somewhat higher than other estimates.

A rather complete report on some American studies for INFCE, covering design and performance characteristics of a variety of fast breeder reactors as well as reactor strategies involving these and other reactor types optimised to minimise uranium consumption, was provided to participants.

A report on the longterm uranium supply and demand situation in Canada suggested that development of fuel cycle technology is urgently required.

8. Summary of the Discussion on the LMFBR - Benchmark

A draft of the proceedings of the ANL Specialists' Meeting had been distributed prior to the NEACRP meeting. Among the discrepancies of major concern are the

- prediction of radial power distribution
- control rod worth calculations

To clarify the situation, at ANL an analysis of the fission rate measurements on ZPPR has been made, resulting in a 1% statistical uncertainty. Calculations of the radial fission rate distribution indicated a C/E difference of 2-4 % on the basis of ENDF/B-IV data. The UK experience on the large all-plutonium assembly BIZET confirmed the UK basis FGL5 in calculating the radial fission rate distribution ; no large differences in the German basis KFK-INR was observed in these experiments with the U.K. results.

Therefore there is no resolution of the discrepancy on radial power distribution at the present time.

On the discrepancy in control rod worth calculations the discussion concentrated first on theoretical methods used. As was presented by the U.K., the proper description of flux perturbation in control rods was able to remove the observed discrepancy with increasing B10 content. Because neither Na nor B data had been adjusted in the "adjusted group sets", there is a need to look in more detail into the precision of these data. Some experiments on far-off C/E values might also indicate some experimental errors.

It was also indicated that there are differences to be expected by applying different processing codes to the same data file as seen from the HEDL/ANL contributions.

The topic of control rod worth discrepancy in the benchmark solutions will be followed up by the Committee.

In a further contribution from Germany on the k_{eff} discrepancy between adjusted and non-adjusted sets, it was shown that small differences from adjusted and non-adjusted data are all of the same sign and are accumulating.

In the discussion which followed it was felt that improvements in differential data measurements to that accuracy which is needed to resolve the situation are hardly to be expected in the near future. In predicting the physics characteristics of a fast reactor, the possibility of using bias factors derived from experience in critical assemblies or adjusted data sets can be used for project work. But it is essential to keep non-adjusted data files and group data sets for further improvements to be included.

H. Küsters

ORGANISATION FOR ECONOMIC
CO-OPERATION AND DEVELOPMENT

NUCLEAR ENERGY AGENCY

SEN/NEACRP/M(79)1
NEACRP-396"A"

RESTRICTED

Paris, 30th October 1979

Or. Engl.

STEERING COMMITTEE FOR NUCLEAR ENERGY

NEA COMMITTEE ON REACTOR PHYSICS

Summary Record of the Twenty Second Meeting held at OECD, Paris, from 1st to 5th October 1979

Delegates

For Canada :

Dr. M. Duret
Atomic Energy of Canada Ltd.
Chalk River

For Japan :

Dr. J. Hirota
JAERI, Tokai-Mura

Dr. T. Inoue
Power Reactor and Nuclear Fuel
Development Corporation, Tokyo

For the United States of America :

Dr. P. Hemmig
U.S. Department of Energy
Washington

Dr. F. Maienschein
Oak Ridge National Laboratory

Dr. C. Till (Chairman)
Argonne National Laboratory

For the countries of the European Communities and the European Commission acting together :

Dr. J. Bouchard
Commissariat à l'Energie Atomique
Cadarache, France

Dr. P. Hammer
Commissariat à l'Energie Atomique
Cadarache, France

Dr. H. Küsters
Kernforschungszentrum Karlsruhe
F.R. of Germany

Dr. J. Debrue
Centre d'Etude de l'Energie Nucléaire
Mol, Belgium

Dr. R. Martinelli
Comitato Nazionale per l'Energia Nucleare, Casaccia, Italy

Dr. J. Askew
United Kingdom Atomic Energy Authority, Winfrith

Dr. C.G. Campbell
United Kingdom Atomic Energy Authority, Winfrith

Dr. H. Rief
CEC, Ispra, Italy

For the other European countries of OECD :

Dr. P. Silvennoinen
(Scientific Secretary)
Technical Research Centre of Finland

Dr. P. Wydler
Eidgenösches Institut für Reaktorforschung, Würenlingen
Switzerland

Dr. G. Velarde
Junta de Energia Nuclear
Madrid, Spain

Nuclear Energy Agency : Mr. J. Rosén
Dr. P. Johnston (Secretary)
Dr. D. Johnson

Observers : Dr. E. Fort (NEANDC)

For Technical Sessions: Dr. Ju Kazanskii (IAEA)
Dr. V. Esimenko (IAEA)

According to a well-established rotation the Belgian participant was representing the three BeNeLux countries and the Finnish participant was representing Denmark, Finland, Norway and Sweden.

Apologies for absence were received from Dr. Khodarev, an IAEA observer.

The meeting was opened by Mr. Rosén on behalf of the Director General of NEA.

Executive Session

1. Committee membership

Dr. Martinelli replaced Dr. Farinelli as the Italian representative in the delegation from the European Communities, and Dr. P. Wydler replaced Dr. Richmond as delegate from Switzerland. The Committee expressed their thanks to Dr. Richmond for his work as Scientific Secretary and welcomed the offer by Dr. Silvennoinen to take over this task.

2. Summary record of the 21st Meeting

The summary record was accepted unchanged.

3. Agenda for the Meeting /SEN/NEACRP/A(79)27

The agenda was adopted without modification.

4. Actions from previous meetings

At a meeting of some members of NEACRP with the bureau of the Data Bank Management Committee to discuss computer program exchange, a recommendation was made that selected new codes of European and Japanese origin should be presented at a seminar in the Argonne National Laboratory, USA. Preparations for such a presentation in February 1980 were described by Mr. Rosén, and welcomed by the Committee.

No report was available on the activities of the IAEA International Working Group on Reactor Radiation Measurements, and the Committee renewed its request that a review should be sought for presentation at its next meeting.

Other actions from previous meetings were completed or were no longer relevant. As in previous meetings the actions concerning preparation of the Committee's sponsored book on Fast Reactor Physics were discussed separately.

5. Activities of other bodies of interest to NEACRP

NEA Data Bank

A report on activities in computer program exchange and nuclear data compilation and distribution was presented by Mr. Rosén /SEN/DATA(79)5/. The Committee also visited the Data Bank for one afternoon where a presentation was made of other activities of the NEA in Reactor Safety, Waste Management and Fuel Cycle studies.

Committee on the Safety of Nuclear Installations (CSNI)

Preparations for a third Specialists' Meeting on Reactor Noise (SMORN III) have continued, with the planned venue in Tokyo in late 1981. An organising committee has been appointed by NEACRP, but the Committee also wished to have a representative from CSNI to coordinate the session devoted to reactor safety aspects of reactor noise.

During the presentation to NEACRP of Reactor Safety activities in NEA, the Committee pointed out that a proposed benchmark exercise oncriticality in 'out of pile' fuel corresponded closely to the NEACRP discussions on this topic. Closer cooperation of NEACRP and CSNI in this field was recommended.

IAEA Division of Advanced Nuclear Power Technology

Although no report on activities was available, the Committee had made a number of contacts during the past year with a view to co-sponsorship of specialists' meetings on 3-Dimensional Rating Distribution Calculations, and on "In-Core" Measurements. Such cooperation on specialists' meetings and in benchmark exercises is expected to continue. As at the previous meeting, two technical observers from IAEA participated in the technical discussions of the Committee.

6. Report on the 21st Meeting of the NEA Nuclear Data Committee (NEANDC)

A report on the Twenty-First meeting of NEANDC (BCMN, Geel, Belgium, September 1979) was presented by Dr. Debrue.

A detailed review of the list of high priority requests for nuclear data had been made by the technical activities subcommittee of NEANDC. This list originated with NEACRP, but had increased in size as more countries contributed their requests. The NEACRP supported the efforts made by NEANDC to restrict the list to a manageable size, but recognised the difficulties in reconciling different request priority criteria. The members of NEACRP were asked to review carefully the requests in the list.

A statement from NEANDC was presented to the Committee expressing concern about restrictions on the release of the new evaluated nuclear data file, ENDF/B-V, outside the USA and Canada. Some particular parts of this file have however been distributed and the previous version ENDF/B-IV is now fully available as a reference file. The Committee acknowledged the concern of NEANDC, but did not feel that any immediate action was appropriate.

A major European conference on nuclear data for technology to be held in BCMN, Geel, in 1981, was being supported by NEANDC.

The Committee drew attention to the fact that the practice of holding such large, general conferences at three-yearly intervals in each major area (Europe, the USA and USSR) meant that they were effectively an annual event. This was contrasted with the slow rate at which items on the request list could be satisfied by measurement, and it was noted that many of the items of interest in reactor application were also the subject of specialist meetings.

NEACRP did not seek to comment upon the value of such meetings to data measurers, but wished to draw attention to the fact that its members did not anticipate being able to make a significant new contribution to a meeting in 1981, and would be sympathetic to an attempt to channel participation by users of nuclear data into meetings on a longer time cycle.

7. Distribution of NEACRP documents

No changes to the established distribution philosophy were made.

8. Renewal of the mandate of NEACRP

The Committee took note of the renewal of its mandate for a further four-year period. The terms of reference were distributed as NE(79)7.

9. Recent meetings of interest to NEACRP

Specialists' Meeting on Homogenisation Studies, Lugano, Switzerland, November 1978.

International Symposium on Fast Reactor Physics, Aix-en-Provence, France; 24th-28th September 1979.

This meeting, co-sponsored with IAEA, was reviewed by Dr. Campbell. Of particular importance to the Committee were the contributions on heterogeneous cores in fast reactors. This topic would be discussed again at the next meeting of NEACRP.

NEANDC Specialists' Meeting on the Cross-Sections of Higher Mass Plutonium and Americium Isotopes, BNL, USA, December 1978.

The proceedings of this meeting had been distributed as NEANDC-L-116.

10. Future meetings of interest to NEACRP

NEACRP Specialists' Meeting on Calculation of 3-Dimensional Rating Distributions in Operating Reactors, Paris, 26-28 November 1979

The preparations for this meeting were well advanced. The emphasis had been placed on comparison of coarse mesh calculations with data from operating reactors, and the Committee welcomed the active participation of nuclear power plant operating companies.

Third Specialists' Meeting on Reactor Noise (SMORN III), Tokyo, late 1981.

A proposed programme was presented to the Committee on behalf of the local organisers. European and USA nominees for the international organising committee would comment on this programme and a meeting would be organised for more detailed planning in 1980. The emphasis of the meeting was on the applications of reactor noise analysis, and a comparison of analyses of a well specified noise recording would be reviewed in one session of the Specialists' Meeting.

ANS/ENS/IAEA Meeting on Advances in Mathematical Methods for solution of Nuclear Engineering Problems.

The Committee expressed the wish that one of its members participate in the selection of contributions to this meeting. Although the subject scope was very large, some aspects were of interest to the specific reactor physics problems studied in NEACRP.

Specialists' Meeting on Fast Reactor Shielding, Paris, late 1980.

A review of activities in Europe and Japan on analysis of iron shielding benchmark experiments was presented by Dr. Campbell. One recommendation of this review was that a specialists' meeting should be organised in 1980. The Committee endorsed this recommendation and nominated an organising committee under the chairmanship of Dr. Hammer.

Specialists' Meeting on "In-reactor" Measurements, late 1981.

It was clear from papers submitted and from discussion in the Committee that significant work was in progress in a number of Member countries, but was in several cases still at an early stage. To allow a closer definition of the scope of a specialists' meeting and to attract the highest quality of contributions, the Committee decided to schedule the meeting for the second half of 1981 and to discuss the topic again and decide the location and topics to be covered at its 1980 meeting.

11. Technical Discussions

Isotopic correlations for fuel exposure history determinations

This topic was discussed for the first time by this Committee and attracted a large number of contributed papers. The emphasis was placed on validation and improvement of the present mainly empirical approach to isotopic correlations, based on a thorough check of reactor physics calculations with experiments to give a complete understanding of the sensitivity of correlations to possible influences from in-pile power fluctuations and out-of-pile conditions.

Criticality problems in storage and transportation in "out-of-pile" fuel

The subject spans a wide variety of activities in "out-of-pile" fuel studies; a common feature was, however, the interest in validation, and possible standardisation, of relatively simple methods for calculation of fuel arrays and solutions. Some benchmark values for heterogeneous arrays are difficult to assess at present, and with very few "ad hoc" experiments available the optimisation of adequate calculational schemes is still in progress. The discussions will be followed up by the Committee in possible collaboration with similar studies initiated by CSNI.

FBR blankets : neutron deep penetration problems

Two topics were discussed; LMFBR reactivity surveillance using ex-core detectors, and determination of spectra and flux for shielding calculations.

LMFBR shielding benchmark analysis

A review of the NEACRP-sponsored programme on shielding benchmark analysis was presented by Dr. Campbell. A specialists' meeting will be held in 1980.

Heterogeneous cores ; including safety-related problems

The contributions to the Aix-en-Provence Symposium on Fast Reactor Physics were reviewed. A detailed summary will be included in the technical minutes of the meeting.

Power peaking

The Committee felt that lack of publications prevented a full appreciation of the state of the art on power peaking, but additional information was expected to be made available in contributions to the NEACRP Specialists' Meeting on 3-D Rating Distributions, to be held 26-28 November 1979 in Paris.

Fuel cycles

The fuel cycle contributions fell into two categories; those dealing with alternative reactor designs, and those dealing with optimisation of existing reactor types. The emphasis in the latter was on specific short-term strategies but some reports on studies for INFCE were also discussed.

National activity reports

The activity reports from each Member country were summarised at the meeting; the full reports will be included in a consolidated document reproduced and distributed by the NEA Secretariat.

12. Technical subjects for the next meeting of NEACRP

- ○ Heterogeneous cores 東芝
  Neutron penetration
  "In-core" instrumentation
- ○ Criticality problems in "out-of-pile" fuel storage and transport 湯本
  Structural materials, reactivity and activation
  Pressurized transient studies
- ○ Problems in the interpretation and analysis of critical experiments 東芝
  Methods of utilisation of information from operating reactors

13. Arrangements for the 23rd Meeting of NEACRP

The meeting will be held at the Idaho Falls Laboratory, USA, from 22nd to 26th ~~October~~ September 1980.

14. Committee officers

Dr. C. Till and Dr. M. Duret were re-elected for a second year as Chairman and Vice-Chairman respectively. Dr.P.Silvennoinen agreed to take over from Dr. R. Richmond as Scientific Secretary.

2. フランス高速炉関係施設訪問

2.1 Cadarache 研究所

1) 日 時 : 10月8日(月) 10時～16時

2) 面会者 :

(フランス側) Mr. Gérard GOURIEVIDIS : Chargé des Relations Exterieures

Mr. J. C. MOUGNIOT : Chef de S.P.N.R

Mr. Philippe HAMMER : Adjoint de S.P.N.R

Mr. J. BOUCHARD : Chef du Service, D.R.E

Mr. Loiek MARTIN-DEIDIER : DRE/SEN (Betiment 238)

Mr. PONTIER : Chef de Rapsodie

(日本側) 井上晃次(動燃)

溝尾宣辰(原研, 高速炉物理研究室)

3) 訪問先および討論:

MASURCA, ERMINE, RAPSODIE 訪問

- MASURCA heterogeneous core を実験中。近い将来2.2 ton core の実験に入る(独の Pu と伊とから協力)。

  Hammer 氏よりFP実験については, 積分測定よりも分離FPによる測定の方に興味を持っている, との発言があった。

- Spent fuel による integral exp の実験装置を入念に見学した。日仏情報交換の可能性……今後の具体化に従って連絡をとる。

- Rapsodie 最近の問題(ここ約2ケ月間停止中)

- 組 織: 高速炉部……付1

  水型炉部……付2

- 入手資料

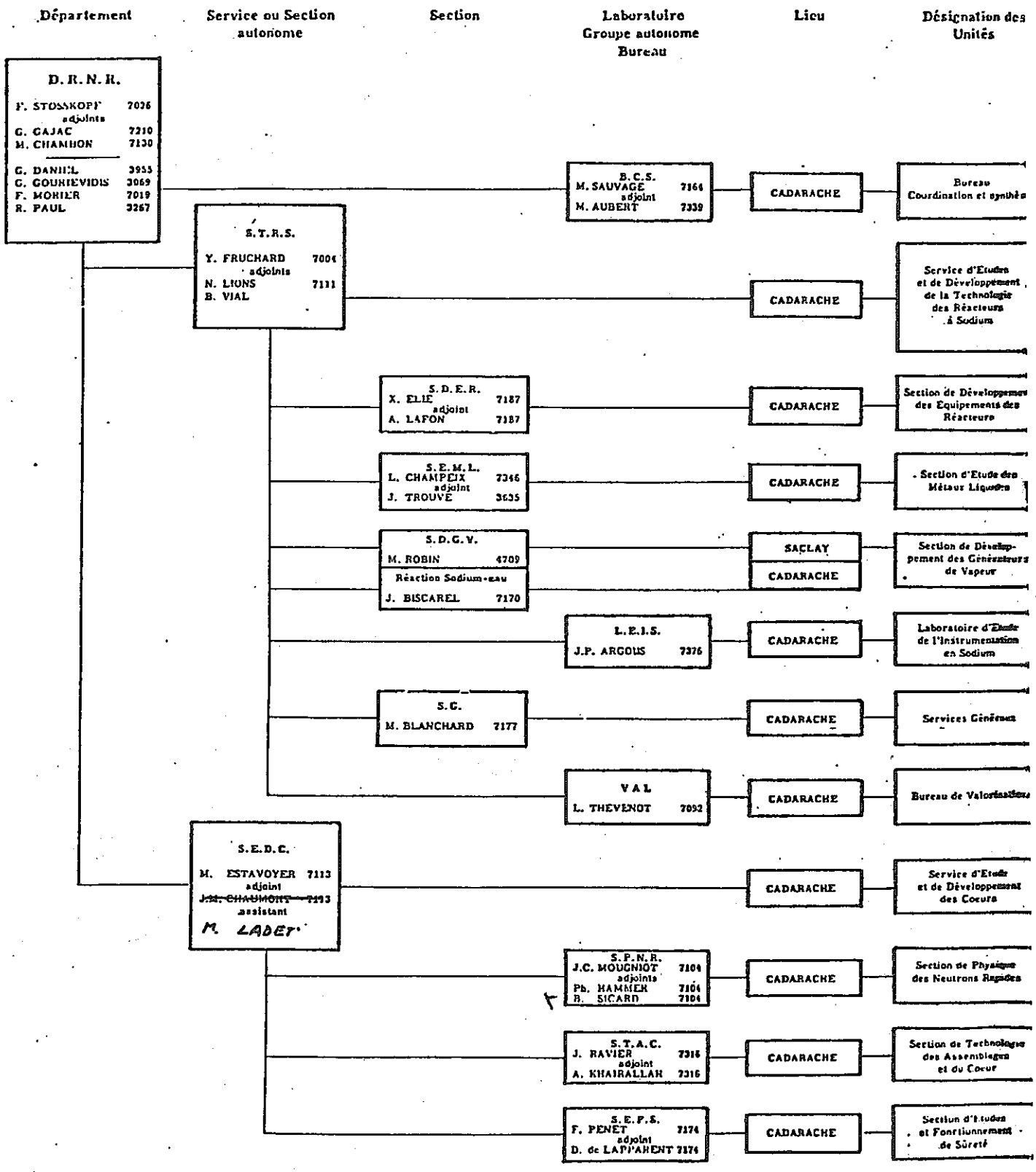
  (1) "Mesure Iutégrale de la Capture des Produits de Fission dans ler Réacteurs á Neutrons Rapides", ORSAY, N° D'ORDRE 2115

  (2) MINERVE, Reacteur Piscine Experimental

  上記2件炉物理Grにて保管

付 1

ORGANIGRAMME DU DEPARTEMENT DES REACTEURS A NEUTRONS RAPIDES



付 2

DEPARTEMENT DES REACTEURS A EAU

Chef du Département : R. VIDAL
Adjoint : J.L. LEROY
Assistant : J. BOYER

SERVICE D'ETUDES DES REACTEURS ET DE MATHEMATIQUES APPLIQUEES

Chef du Service : M. CHABRILLAC
Adjoint : A. KAVENOKY

- SECTION D'ETUDE DES REACTEURS A EAU LEGERE
  Chef de la Section : J.P. SCHWARTZ
- SECTION DE PHYSIQUE MATHEMATIQUE
  Chef de la Section : A. KAVENOKY
- LABORATOIRE D'ETUDE DES PROTECTIONS
  Chef du Laboratoire : J.C. NIMAL

SERVICE D'ETUDES NUCLEAIRES

Chef du Service : J. BOUCHARD
Adjoint : G. FREJAVILLE
Assisfants : M. ROBIN
C. GOLINELLI

- LABORATOIRES DE PHYSIQUE EXPERIMENTALE
  Responsable : G. FREJAVILLE
  Chef des Installations : R. BOYER
- LABORATOIRE DE PHYSIQUE APPLIQUEE
  Chef du Laboratoire : C. FICHE
- LABORATOIRE D'ETUDES DE CONTAMINATION DES CIRCUITS
  Chef du Laboratoire : P. BESLU
- LABORATOIRE DE MESURES SUR LES COMBUSTIBLES IRRADIES
  Chef du Laboratoire : D. HEBERT
- LABORATOIRE DE PROPULSION NAVALE
  Chef du Laboratoire : R. CANTALOUBE
- LABORATOIRE DE PHYSIQUE DES REACTEURS A EAU
  Chef du Laboratoire : M. DARROUZET

SERVICE DE TECHNOLOGIE DES REACTEURS A EAU

Chef du Service : R. GINIER
Adjoint : J.L. CAMPAN
Assistante : Mme D. MENESSIER

- LABORATOIRE EXPERIMENTATION ET SUPPORT
  Chef du Laboratoire : J.L. CAMPAN
- LABORATOIRE HYDRAULIQUE ET INSTRUMENTATION
  Chef du Laboratoire : M. PONTIER
- LABORATOIRE DE MECANIQUE ET DE THERMOHYDRAULIQUE APPLIQUEES

2.2 Crey-Malville（Super-Phenix 建設現場）

1) 日　時 ： １０月１０日（水）　１０時～１７時

2) 面会者 ：

（フランス側） Mr. Jean DECUYPER : Chef du Service Fonctionnement et Essais, NERSA

Mr. Renée XAUIER-HÉLÉNE-MARIEFIERRE; NERSA

Mr. Jean TONNER : Relations publique NOVATOME

（日本側） 井上晃次

3) 内　容：

o 午前中，NOVATOME側より一般概況説明，ATELIERを見学，NOVATOME １９７６年設立，資本金１０,０３２,０００FF（約5.5億円）

分担は次の通り

Crensot Loire	３６％
CEA	３４％
NEYRPIC	１５％
ALSTHOM ATLANTIQUE	１５％

Staffは約８００名，このうち約半分は high school 出身で高速炉の平均経験年数は１１年である。

NOVATOME responsability of supply

— Reactor Block

Vessels-Internals-Phugs-Dome

— Primary Circuit

IHX-Pumps

— Secondary Circuits

Pumps-Steam Generators

— Associated Auxiliary and Secondary Circuits

— Fuel Handling System

Loading ／ Unloading-Storage-Transfer

— Monitoring and Safeguard System

— Fuel

— Steam condition の責任がある。balance of plant は NOVATOME の外

○ Site Workshop を付1および付2に示す。

○ 午後，NERSAの人により建設現場案内 （Site Workshop）

Site Workshop では main vessel，core support structure，cooling baffle，inner vessel，Roof slab，fuel storage 関係，rotating plug などほぼ製作完了に近い。

格納容器はほぼ一番上のところ迄立上った。あとは屋根をつけるところ，今年12月初又は来年初頃安全容器，主炉容器，炉構造支持部の取付，来年に入って主炉容器冷却用バッフルなどが持ち込まれる。一番重いものルーフでコンクリートなし800ton，コンクリートありで3000ton，この部分は water cool される。

現場は工事活動の最盛期。

380kV 2系統独立受電の建物は並列に建物が完成，内装配線関係はこれから。格納容器水冷却工事難行，又主炉容器厚さの妥当性の議論もある模様

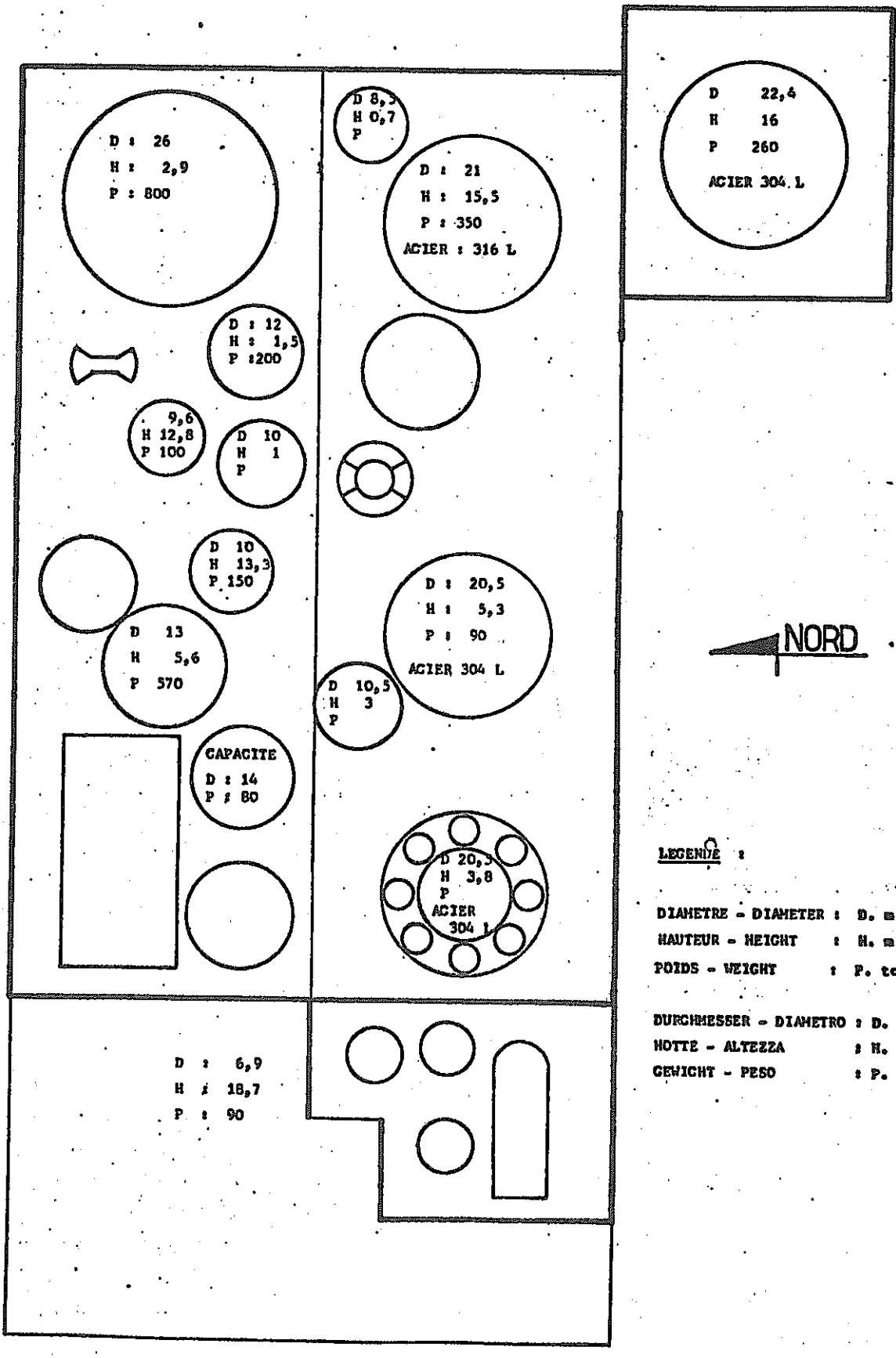
○ Site location は付3に示す通り。

Lyon の東，約50kmのところにある。

付 1

ATELIER SITE

DIMENSIONS : L 114 m
l 75 m
H 38 m



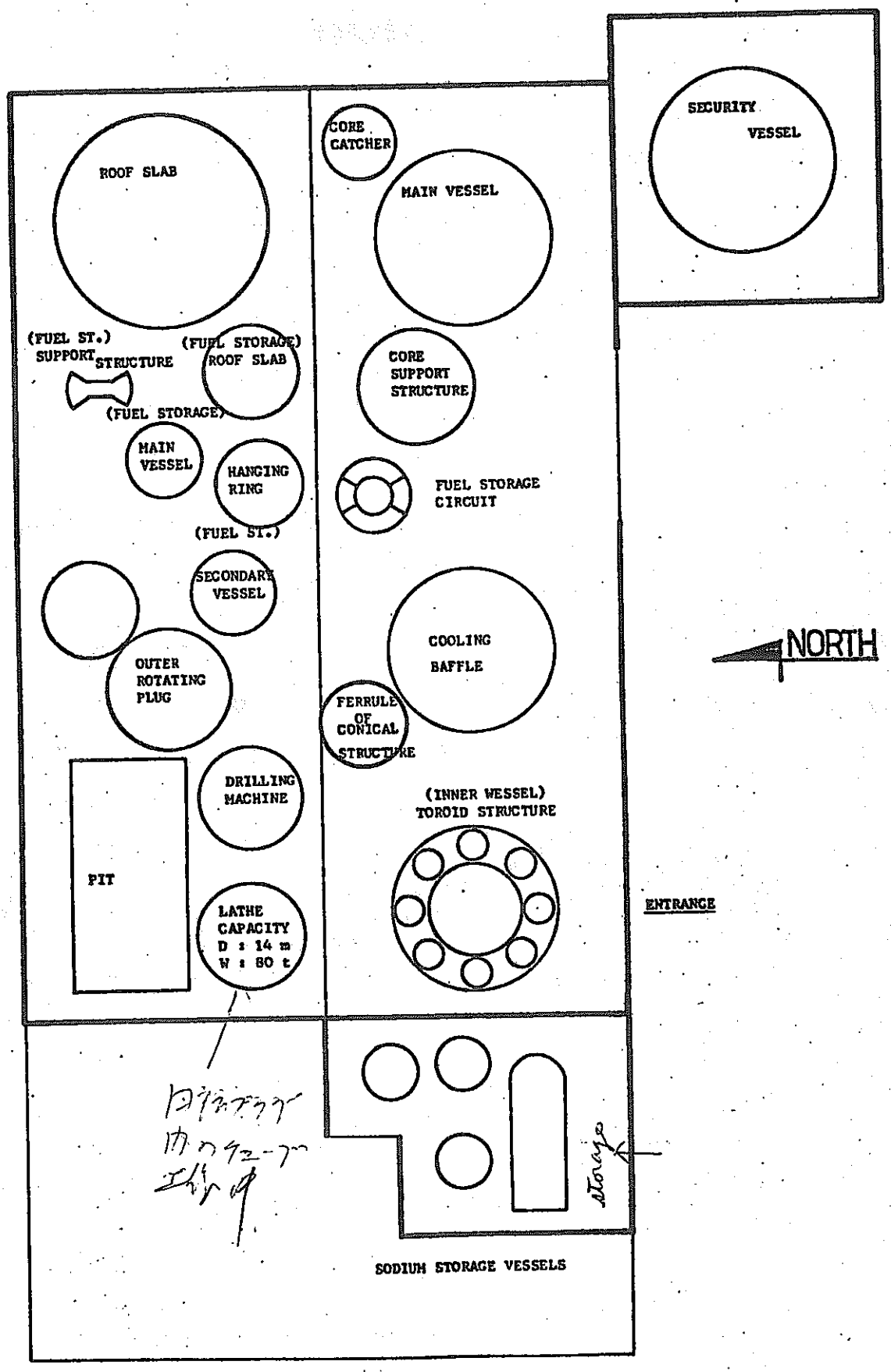
LEGENDE :

DIAMETRE - DIAMETER : D. m
HAUTEUR - HEIGHT : H. m
POIDS - WEIGHT : P. tons.

DURCHMESSER - DIAMETRO : D. m
HOTTE - ALTEZZA : H. m
GEWICHT - PESO : P. tons.

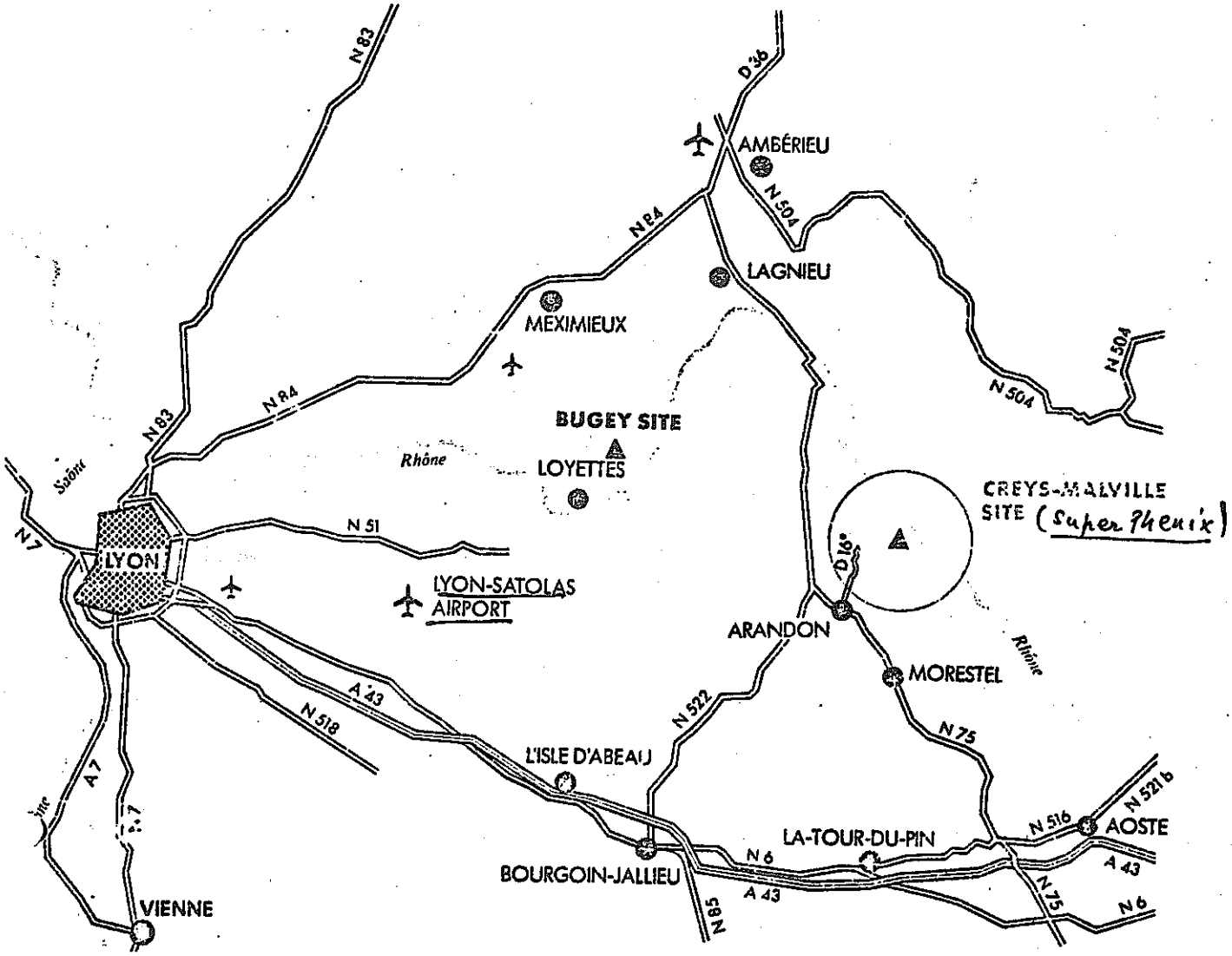
付 2

SITE WORKSHOP



付 3

site location



general view

2.3 NOVATOME 本社

1) 日 時 : 10月12日(金) 10時～16時

2) 面会者 :

(フランス側) Mr. Jean LEDUC : Direction des Projets 部長

Mr. Pierre CLAUZON : Chef de la Division Etudes Générales

Mr. Jean JÉGU : Chef du Sorvice coeur et Protection

Mr. Henri NOEL : Chef du Service Sureté

Mr. Jacques GOLLION : Ingénieur en Chef

(日本側) 井上晃次

3) 内 容 :

○ 組織 付1 & 付2 参照

○ 大型 LMFBR の炉心設計について

Pierre Clauzon 氏

Chef de la Division Etudes Général

Jean Jégu 氏

Chef du Service Eoeur et Protection

Clauzon 氏より Super Phenix Ⅱ 活動現状証明

① 最初の段階

1800 MWe ペレット径 5.5 ㎜

CEAで設計研究

homogeneous core と heterogeneous core が同等に研究された。

heterogeneous core の目的は

○ BR, DTの改善

○ fuel residence time をより長くすること

○ 経済的燃料サイクルの確立

であった。

② NOVATOME の activity に移行

1500 MWe ペレット径 5.5 ㎜, △P 7 bars

△T 165 ℃, H 100 ㎝

これは homogeneous も heterogeneous で，以上の条件で設計研究をしていたが，その後パラメーターサーベイを度々行い，ペレット径は Phenix の 5.5 ㎜か Super-Phenix Ⅰ の 7 ㎜へ，△P は 9, 7, 5 bars，△T は 160 ℃ fixed で行った。

③ Super-Phenix-Ⅱ の特性

パラメータサーベイの結果

ペレット径 7 ㎜，H 100 ㎝，△P 5bars，△T 160 ℃，BG 0.21 におさまりそうだ。

（△P を 7 bars にして BG を 0.24 にしうる見通しであったが Pump の経済性の方からだめ）

④ 経済性に重点

Custmer は BR，DT の要求は余り強く云わない。

プラントの経済性により重点をおいている。

（KW 当りの発電単価を Super Phenix Ⅰ より 30％下げるよう要求されている，

Super Phenix 1　NSSS　3 mill FF/kWe

Super Phenix 2　〃　−30％

F. Descemps 氏の説明）

したがって，BR，DT は Super Phenix 3 又は 4 で改善していく。

⑤ heterogeneous core について

Custmer は BR，DT に興味がない。したがって ecomic cycle の少しの gain がない。遠い将来 Phenix で確かめるか，又は Super Phenix 1 又は 2 でも 10 年位後に延ばしてしまうことになろう。（CEA本部訪問の際にも J. Y. Barré 氏の証明あり）

⑥ Blanket の配列

Custmer は Blanket を厚くする要求をしている。

Radial を 1 列，それに SS と置き換え可能な Blanket をもう 1 列おくことになるだろう。

axial は上下各 30 ㎝から上部 20 ㎝，下部 30 ㎝にするよう NOVATOME は提案している。（EDF は上部 10 ㎝，下部 20 ㎝でよいとしている）

⑦ linear heat rate

Super Phenix 1 の 450W/cmから Super Phenix 2 では 530W/cm に上昇させる。これは同径ペレットで穴あきを検討中，これはまだ非公式。炉容器の大きさが相当小さくなる。Super Phenix 3 では 600W/cm 以上をねらうだろう。

⑧ Shields

炉心下部の support grid が厳しい。

lower blanket の厚さを減少している。

upper part には Boron carbide を用いることを検討中，しかし，まだ問題がある。

ピンに入れるかどうか。

⑨ Nuclear calctlation

CEAからくるものをそのまま使っている。

核データは CARNAVAL Ⅳ 25 gr 1次元か 6 gr 2次元の Dipp 計算

Super Phenix 1 のときは全部CEAの人がした。

〃 2は最初から NOVATOME でやる。

⑩ design limit

	Phenix	SP1	SP2
○ nominal clad taps (clad 中心)	650℃	620℃	650℃
○ hot rpot を考慮すると	700	700	700
○ DPA (clad の fluence)			
運転上の nominal	90	127	150
mechanicd design			90
○ Burn up			

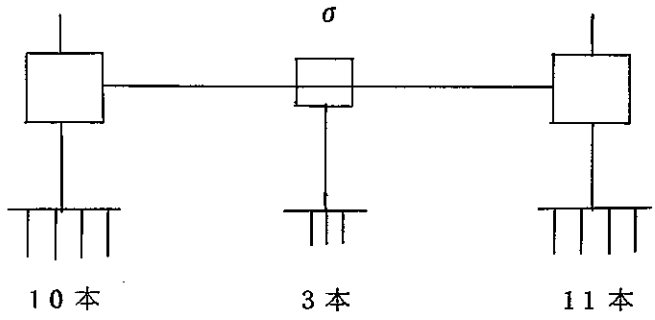
○ 大型 LMFBRの安全性

Henri Noel

Chef du Service Sureté

① ＨＣＤＡはやめたい

制御棒のＲ＆Ｄと設計の改善を Σ_i Pn ATWS は 10^{-10} 以下になる見通し



最近の設計では3系統のCRを持っており，信頼性が上昇した。但し，Common mode failure は考えていない。又，Pump の mechanical enertia は 50 sec もあり，Pony moter をつなぐと boiling は起きない。

② Faulted Plant condition

イ loss all secondary loss

ロ one S/A accident

ハ sodium fires (secondary と auxiliary fuel storage)

ニ leak of the main vessel in normal operation

ホ earthquake

ヘ aircraft crash

ト Na-H_2O SG

ニ：Safety Vessl の DBA

ハ，ホ，ト：Containment Vessel の DBA

③ Safety criteria

draft に対して CEA，EDF，NOVATOME が comments を出している段階。まだ open に出来ない。来年，再検討されたものが出される。

④ Core catcher

Super Phenix 1 と類似のものが必要であろう。

○ Periodical Inspection

M. Boulinier 氏

Correspondant Phenix in NOVATOME に頼んだ。

○ NOVATOME の紹介とフィルム

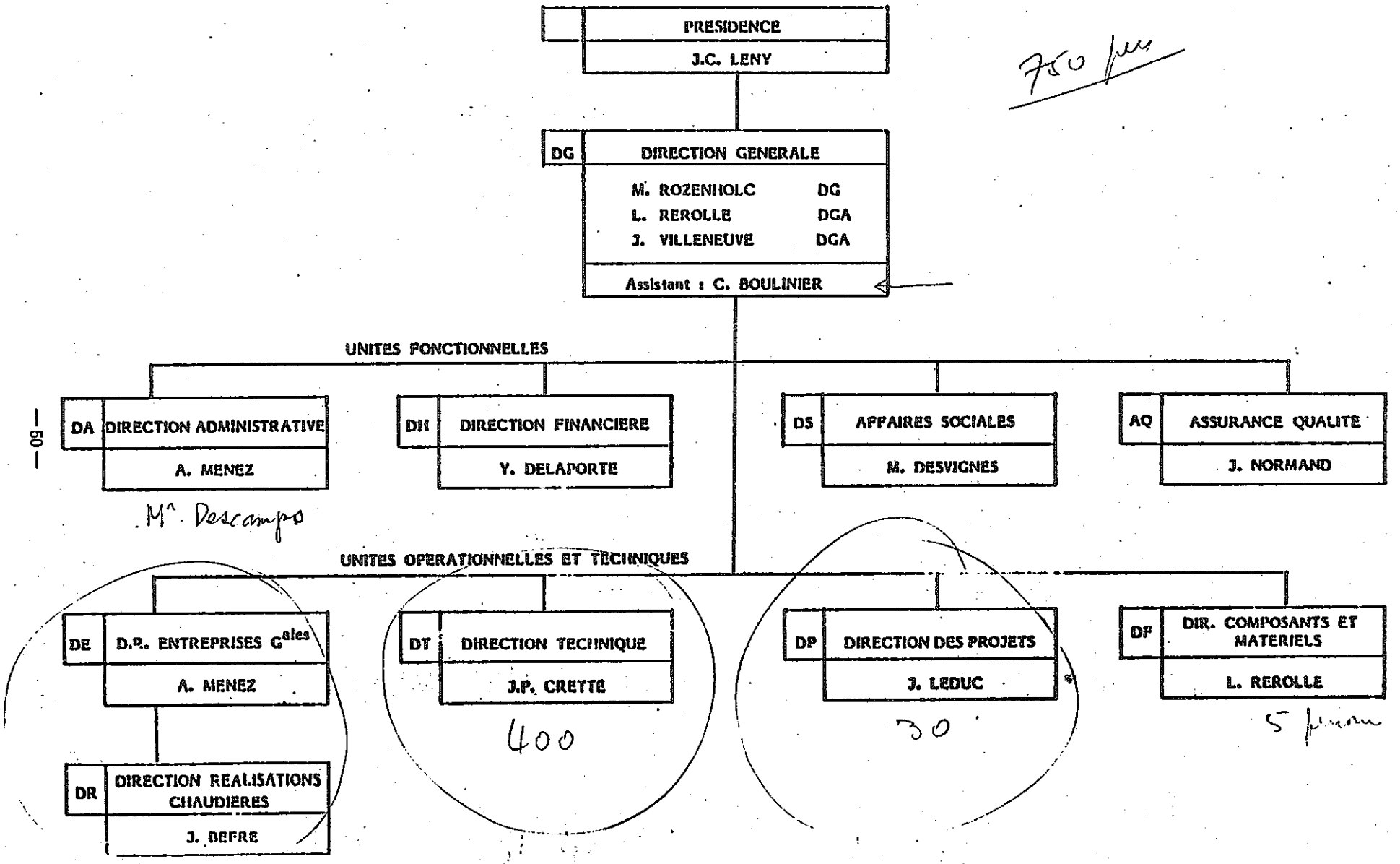
Francois Descamps 氏

Département Entreprises Générales

novatome

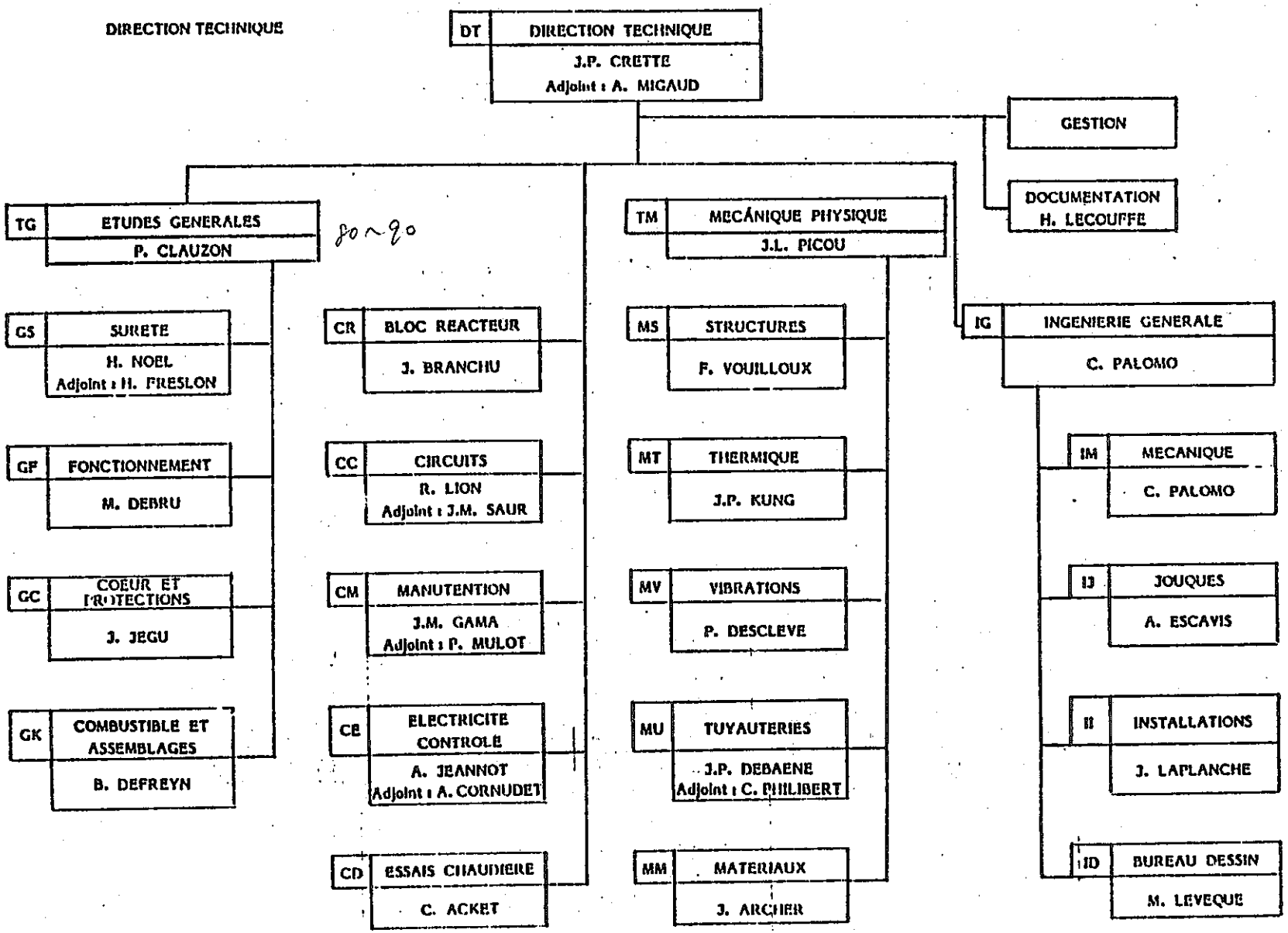
ORGANIGRAMME GENERAL

41



novatome

DIRECTION TECHNIQUE



1er Juin 1979

付 2

3. "The Breeder Reactor and Europe" 国際会議

1) 場　所：スイス，ルッツェルン

2) 出席者：１６ケ国，１６６名　欧州の産業界の人が多かった。（日本からは小生と東芝佐々木氏）

3) 期　間：１０月１４日（日）～１０月１７日（水）

4) 内　容：（プログラム付）

10/14(1) Opening remarks, Dr. N. Franklin, Chairman, Nuclear Power Co. Ltd., Risley

ＦＢＲは１９８０年代に demonstration に入るが cost が問題，western europe は full scale の demo plant を政府による national supply として実現しうるかどうか。

(2) Nuclear Fnergy：Resources and Demand Dr. P. Graf, Excutive Vice President, Head Nuclear Engineering Div., Motor-Columbus Consuting Engineers, Inc., Baden.

１９７７年 World Energy Conf と INFCE WG5 final report の要点を説明，但し，最後の頃 GCFBR の経済性を強調。

（質疑）① R. D. Smith GCFBR が何故 low cost か，取扱いは確かに easy だが，timescale は長い。

② Rapin（CEA）thermal reactor は develop させるべきだ，LWR をいつまで続けるか，まだ結論をもっていない。LWR再処理 Pu を提供する。１０～２０年位は必要，ＦＢＲ開発は１０年以上かかる。他の国はもっとかかっているだろう。議論を待っている国を余り理解出来ない。とに角，時間がかかる。Energy market in Europe は非常に難しいと思う。

(3) The Uranium-Plutonium Breeder Reactor Fuel Cycle, Dr. A. Salmon, Assistant Director, Reprocessing Division, BNFL, Risley

UKでのU需要 { Magnox, AGR, PWR 今後５０年で　５００ kt
　　１９９５　FBR が入れば　　２５０ kt

Out of reactor time 短縮，main fuel cycle plants，reactor 特性，decay heat（BU，Time 依存），Fuel assembly（Super-Phenix，CDFR）fabrication of fuel assembly，ヨーロップ２５年の経験 reprocessing，

waste management, transport などごく平易な内容の説明，最後に thermal reactor 用の reprocessing はUKの中で international に avalable であると結んだ。

（質疑） (1)フランス・コジマの人：ＦＢＲ製造コストはＬＷＲと比較してより大きいと述べているが賛成できない，英国はバイバックで振動充てん法，ブレンディングは powder からペレットにして製造する方がよい。理由は enrichment の違う製造が必要だし，isotopic composition も違う，他

(4) Alternative Nuclear Fuel Cycles and Gas Cooled Breeders, Dr. B. Pellaud, Managing Director, General Atomic Europe, Zurich

GCFBRにＴｈを使ってＵ233を生産し，これをHTGRのAdvanced converter reactorに使用することによりHigh CRをうるという話（独，日本原研でstudyあり）。LMFBRのback upとして必要。HBA（Helium Breeder Associates）が１９７６に形成され，活動中。

（質疑） Th系，metal系のreprocessing，multi-reactor systemのcostなどで質問あり。仏，utilityの人から多数のfuel cycleを含む原子炉系は炉の特性はよくても out of reactor の遅れがはげしく使いものになるか…など。

(5) How to build an LMFBR Power Plant

J. Befre, Directeur des réalisations des chaudieres nucléaires, Novatome（フランス語）

Super-Phenix 建設の組織，組立の順序など説明，ＳＧなどmain componentのPhenixとの違い説明。

claddingはチタンstabilized 316，transient temp dis難しくtestが行われた。ＳＧはINCONEL８００から改良したhigh chrome & nickel content alloy，roof slab ２４m直径，2.９m高さ，８５０ton。

工場は１９７８年6月完了し，作業は１９８０年末迄続く。

Organization NERSA－NOVATOME, NIRA

スケジュール
- completion of component assembly and installation　１９８１～１９８２
- sodium filling　mid １９８２
- commercial plant の commissioning　１９８３

（質疑） ①スイスの人，HCDA 800 MWsec の件…… Ans．これは1973頃の評価，その後多数の試験などあり，今は考え方は違う。

② Franklin：NOVATOMEのギランティーについて，Ans．それぞれのmaker がする。例えI燃料はコジマ。

③ Franklin：SG Na中の helical coil の溶接点の数…… Ans．3000個位（25φ 60m の tube を3ケ所で溶接，SG4基）

10/15(6) IAEA Breeder Reactor Activities，Prof，Zheludev I．S．Deputy Director General，IAEA

IWGFRの活動紹介，最初の demo FBRはSGを大きくする必要はない，軽水炉からの Puが多量にある。将来は high BG 必要

(7) Safety Aspects of LMFBR Design，Dr．R．D．Smith，chief Technologist，UKAEA，Dr．E．C．C．Cobb，Nuclear Power Co．Ltd．，Risley

Smith から主として炉物理上の特徴を説明，Cobb 氏より plant 系の説明，極めて初歩的なものだった。

2～3基礎的な質疑あり。

(8) The Status of Breeder Safety，P．Tanguy，Dinecteur de l′Instetut de protetion et de sureté nucléaire，CEA

① FBRとLWRとは同じ，1～4次迄の barrier，Crey-Malville lécensing process

② Fast Breeder Safety assessment lowpressure，secondaryloop 利点，compaction of core 欠点，10^{-6}の確率でDBAの境界，これより highly の hypothetical large accidents をとるべきではない。（LWRラスムッセン 10^{-4}～10^{-5}／reactor year） TMIのように，もっと確率の高い accidentに注意を払うべきだ。

③ Design accidents（Category 4）

イ Natural events：地震，air-craft など containment

ロ loss of normal cooling circiuts

external power sources なしでDHR可能のこと。

ハ leak in the main vessel in operation

pool-type design の特徴

ニ Melting of a limited number of fuel S/A

1本は考えるべき，propagate しないか検討すべき。

ホ SG中での $Na-H_2O$ reaction

ヘ Sodium fires

④ HCDA

shut down system 1，2次＋auxiliary system

ある人はHCDA，再臨界，melt down を考えている。

Crey Marville …… Fmergency DHR，shut down system，cal.of HCDA 検討中 …… CABLI 計画

⑤ State of knowledge of Safety issues

運転経験 …… 原型炉タイプが必要

fuel cladding integrity：良好

core coolability：pool type で成功

core monitoring：TMI 良くない，FBRは良い（TC）

containment integrity：試験中

Na エアロゾル

Na fire

⑥ 結論 Seattle meeting と同じ。

（質疑） ISI，DHR，ラスムッセン報告，などで質疑あり。

(9) Breeder Programmes（以降質疑なし）

① The French-Italian-German-Belgian-Dutch

Construction Programmes，Prof.M. A. Rapin，Directeur délégué aux applications énergétiques nucléaires，CEA

フランスのエネルギー源，欧州内協力関係，Super-Phenix 2-1983 頃 Commercial Breeder Line，EDF 1500MWe 1985前に発注の意向，Fuel Cycle も含めたもの。

Fuel fabrication，reprocessing，waste など fuel cycle の今後の計画説明，国際協力を望むと結ぶ。

② The French-German-Belgian-Dutch-Italian

Breeder Research and Development Programmes Dr. H. H. Hennies，

Karlsruhe

DEBENEとFranceの協力関係，各種R＆Dの説明

③ The UK Breeder Programme, J. Moore, Director, Fast Reactors, UKAEA

1950年からのUKの活動を説明，特にDFRでのU-Pu Oxideの照射実験が20%BUを越えて行われたことを強調，CDFRは1984頃 strategic judgementがある。

④ Development of Fast Breeder Reactors in the USSR

L. A. Kochetkov, State Committee on Atomic Energy

FBRの必要性，BR-1, -5, physics mock up BFS, BFS-2, BOR-60, BN350, BN600の説明，BN600は start upの段階

⑤ Current Status of LMFBR Development in Japan, T. Inoue

⑥ Status of U. S. Breeder Programme, Dr. R. B. Richards, GE

付 1

Swiss Association for Atomic Energy (SVA)
Association Suisse pour l'Energie Atomique (ASPEA)
Schweizerische Vereinigung für Atomenergie (SVA)

Association of European Atomic Forums
FORATOM
Forum Atomique Européen

International Conference

The Breeder Reactor and Europe

14–17 October 1979

Palace Hotel, Lucerne (Switzerland)

If nuclear power is to play a major role in meeting world energy needs in the long term, clearly thermal converters must with time be complemented with more advanced reactor systems that conserve uranium resources, which are huge but not unlimited. This in itself is unquestioned. Disagreement begins with discussion of the desirability of the breeder, as well as how fast and how far the introduction of these new reactors should go.

With this conference the Swiss Association for Atomic Energy (SVA) and the Forum Atomique Européen (FORATOM) as co-sponsor would like to show the importance of the breeder for Europe and to deepen and broaden knowledge on this subject. From a technical and economic point of view, the meeting will present the basic facts of fast breeder technology, introduction strategies, commercial and safety aspects, as well as the breeder programmes of the countries active in this field. Based on this, the participation of all the important organisations will enable a distinguished panel discussion to take place on the fast breeder's status and the outlook for Europe.

The meeting will be of special value to representatives of utilities, industries, engineering and consulting companies, as well as authorities with a broad interest in the overall breeder problem.

Programme

Sunday, 14 October 1979

17.00–20.00 *Check-in*

19.30–21.00 *Reception*

Monday, 15 October 1979

08.30 *Check-in*

10.00 Opening remarks by the chairman of the Conference

Dr. N. Franklin, Chairman, Nuclear Power Co. Ltd., Risley

Why to breed?

10.10 **Nuclear Energy: Resources and Demand**

(Energy demand forecasts for Europe and the world, possible role of nuclear fission energy, short- and long-term strategies of breeder introduction)

Dr. P. Graf, Executive Vice President, Head Nuclear Engineering Div., *Dr. H. B. Baumberger,* Vice President Economics and Develop Planning Div., and *K. P. Gibbs,* Chief Expert, Nuclear Engineering Div., Motor-Columbus Consulting Engineers, Inc., Baden

11.10 *Discussion*

11.30 **The Uranium-Plutonium Breeder Reactor Fuel Cycle**

(Closure of the breeder fuel cycle, reprocessing of fuel and breeding elements, recycling of LWR-Pu, special waste problems, the Pu-nuclear fuel market)

Dr. A. Salmon, Assistant Director, Reprocessing Division, British Nuclear Fuels Ltd., Risley, and *R. H. Allardice,* Deputy Director, Dounreay Nuclear Establishment, United Kingdom Atomic Energy Authority, Dounreay

12.40 *Discussion*

13.00 *Luncheon*

14.30 **Alternative Nuclear Fuel Cycles and Gas Cooled Breeders**

(Th-U-cycle, Th-resources, other cycles, the HTR as near-breeder, HTGBR, fusion-fission-hybrid concepts)

Dr. R. C. Dahlberg, Director, Fuel Engineering Division, General Atomic Co., San Diego, and *Dr. B. Pellaud,* Managing Director, General Atomic Europe, Zurich

15.15 *Discussion*

15.30 *Coffee break*

Breeder Reactor Technology I: Construction

16.00 **How to Build an LMFBR Power Plant**

(Main components, material questions, industrial aspects)

J. Befre, Directeur des réalisations des chaudières nucléaires, Novatome, Le Plessis-Robinson

17.10 *Discussion*

17.30 *End of first conference day*

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Breeder Reactor Technology II: Safety

09.00 **Safety Aspects of LMFBR Design**

(Inherent safety, engineering design features incorporated to meet safety requirements, built-in safety features; structural integrity, redundance, inspection)

Dr. E. C. C. Cobb, Nuclear Power Co. Ltd., Risley, and *Dr. R. D. Smith*, Chief Technologist, Fast Reactors, United Kingdom Atomic Energy Authority, Risley

10.00 *Discussion*

10.20 *Coffee break*

10.50 **The Status of Breeder Safety**

(Main safety features, possible accidents, hypothetic accidents, core melting and secondary criticality, conventional accidents in LMFBRs)

P. Tanguy, Directeur de l'Institut de protection et de sûreté nucléaire, Commissariat à l'énergie atomique, Fontenay-aux-Roses

11.50 *Luncheon*

Breeder Programmes

(R & D programmes, present status, plans, non-proliferation and other political considerations—question time)

13.40 **The French-Italian-German-Belgian-Dutch Construction Programmes**

Prof. M. A. Rapin, Directeur délégué aux applications énergétiques nucléaires, Commissariat à l'énergie atomique, Paris

14.20 **The French-German-Belgian-Dutch-Italian Breeder Research and Development Programmes**

Dr. H. H. Hennies, Mitglied des Vorstands, Kernforschungszentrum Karlsruhe GmbH, Karlsruhe

15.00 **The UK Breeder Programme**

J. Moore, Director, Fast Reactors, United Kingdom Atomic Energy Authority, Risley

15.40 *Coffee break*

16.10 **Soviet Union**

Representative of the State Committee on Atomic Energy, Moscow

16.40 **Current Status of LMFBR Development in Japan**

T. Inoue, Senior Staff Engineer and Head of the Fast Reactor Physics Branch, Power Reactor & Nuclear Fuel Development Corporation, Tokyo

17.00 **Status of U.S. Breeder Programme**

Dr. R. B. Richards, General Manager, Advanced Reactor Systems, General Electric, Sunnyvale

17.30 *End of second conference day*

18.30 *Evening event*

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The Breeder Reactor and Europe: Political and Commercial Aspects

(Panel discussions on the following subjects: the need for breeders—non-proliferation issues—basic research requirements—international technical cooperation—commercialisation of the LMFBR technique—how to come down with the bulk investment costs—fuel cycle implementation)

Panelists: *Dr. N. Franklin* (chairman); *Dr. U. Däunert*, Bundesministerium für Forschung und Technologie, Bonn, *Prof. Dr. H. Grümm*, International Atomic Energy Agency, Vienna, *M. Rapin; Dr. A. W. Eitz*, Schnell-Brüter-Kernkraftwerksgesellschaft mbH, Essen, *R. H. Fillnow*, Westinghouse Electric Corporation, Madison, *J. Leduc*, Novatome, Le Plessis-Robinson, *J. Moore*, a. o.

08.30 **Panel I**

10.00 *Coffee break*

10.30 **Panel II**

11.30 Closing Remarks by the Chairman of the Conference

11.45 *End of Conference*