

File A11



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

OCT 24 1979

Generic Task No. A-11

MEMORANDUM FOR: V. S. Noonan, Chief, Engineering Branch, DOR  
THRU: W. S. Hazelton, Section Leader, Engineering Branch, DOR  
FROM: R. E. Johnson, Engineering Branch, DOR  
SUBJECT: TRIP REPORT:

CSNI SPECIALIST MEETING ON PLASTIC TEARING INSTABILITY

Dates: September 25 - 27, 1979

Place: Washington University, St. Louis, MO.

Attendees: See list (Enclosure 1); participation was by invitation.

The writer attended the meeting on Plastic Tearing Instability called by the Committee on the Safety of Nuclear Installations (CSNI) of the OECD Nuclear Energy Agency. Background details can be found in Enclosure 2, copies of the cover and page 3 of the meeting notice.

The technical program is shown here as Enclosure 3. There were some changes in the final program (some switching and some additions occurred) but they were relatively minor. Rather than include commentary on the program in this Trip Report, anyone interested in specific papers may contact me and we can review notes taken at the meeting.

What may have been the most important part of the meeting was the Conference Summary. The object was to reach conclusions with a view of transmitting them to CSNI as recommendations. Although responsible individuals will no doubt polish the conclusions prior to publishing them, they should be close to the notes I made during the session, given here as Enclosure 4. By reaching the conclusions, the CSNI specialists have provided advance, international, approval to the thrust of the TAP A-11 final NUREG.

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The entire technical program, including session chairmen summaries of each session and the meeting conclusions/recommendations, will be published promptly as an NRC NUREG Report.

*Richard E. Johnson*

Richard E. Johnson,  
TAP A-11 Manager  
Engineering Branch, DOR

Enclosures:

1. Attendees List
2. Background Details
3. Technical Program
4. Notes from Session

cc w/enclosures: See next page

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cc w/enclosures:

S. Hanauer  
M. Aycoc~~k~~  
D. Eisenhut  
V. Noonan  
L. Shao  
J. Stronsnider  
R. E. Johnson  
R. Gamble  
P. Leech  
P. Kapo  
R. Klecker  
W. Hazelton  
J. Knight  
P. Check  
S. Pawlicki  
W. Regan  
J. Watt  
S. Varga  
P. Randall, OSD  
C. Serpan, RES  
Accessions Unit (016)  
EB Members

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OECD/CSNI, WASHINGTON UNIVERSITY IN ST. LOUIS, U.S.A., SEPTEMBER 25-27, 1979List of ParticipantsAUSTRIA

Rieger G. OSGAE, Vienna

CANADA

Jarman B Atomic Energy Control Board, Ottawa  
Panesar J.C. Atomic Energy of Canada, Mississauga, Ontario

FINLAND

Ranta-Maunus A. Institute of Radiation Prot., Helsinki

FRANCE

Bhardari S. Novatome, Robinson  
Cheissoux J.L. C.E.A. Cinnussaruat a K-Energ. Atom. St. Paul Les Durance  
Faicy C. Electricity of France, LaDefense  
Pineau J. Ecole Nat'l Super Des Mines, Cedex  
Pellissier A. Framatome, Paris  
Roche R.L. CEN Saclay, Gif Sur Yvette  
Oliver P. OECD, Nuclear Energy Agency, Paris

NETHERLANDS

Bakker A. Potter Damseweg, Al Delft

ITALY

Conti M. CNEN, RAD, RSI, IN GIMP, Rome  
Zampini G. NIRA, Genova  
Lamain, L. Commission of the European Communities  
Joint Research Center, Ispra Establishment, Varese

SWEDEN

Carlsson J. The Royal Institute of Technology, Stockholm

WESTERN GERMANY

Blaue J.G. Institut fur Festkorper Mechanik, Freiburg  
Azodi D. Gesellschaft fur Reaktoricherheit, Koln

UNITED KINGDOM

Milne I. Central Electricity Research, Leatherhead Surrey  
Bevitt E. UKAEA (SRD) Culcheth  
Irvine W.H. UKAEA (SRD) Culcheth  
Ingham T. UKAEA (RNL) Risley  
Fulford I. Rolls Royce & Assoc.Ltd., Derby  
Howard I. University of Sheffield, Sheffield  
Rose R.T. Nuclear Power Company, Cheshire  
Turner C.E. Imperial College of Science & Technology, London  
Garwood S.J. The Welding Institute, Cambridge

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U S A

Albrecht	P.	Nuclear Regulatory Commission, Washington DC
Johnson	R.	Nuclear Regulatory Commission, Washington DC
Loss	F.H.	Naval Research Laboratory, Washington, DC
Gudas	J.	David W. Taylor Naval Research, Annapolis, Md.
Wessel	E.T.	Westinghouse R&D, Pittsburgh, Pa.
Landes	J.	Westinghouse R&D, Pittsburgh, Pa.
Hutchinson	J.W.	Harvard University, Cambridge, Mass.
Irwin	G.	College Park, Md.
Shih	F.	General Electric Co., Schenectady, NY
Joyce	J.	U.S. Naval Academy, Annapolis, Md.
Merkle	J.G.	Union Carbide Corporation, Oakridge, Tenn.
Zahoor	A.	Battelle Columbus Lab, Columbus, Ohio
Norris	D.	Electric Power Research Institute, Palo Alto, Calif.
Bloom	J.	Babcock & Wilcox, Alliance, Ohio
Chen	A.	Sandia Laboratories, Albuquerque
Szabo	B	Washington University in St.Louis, Mo.
Paris	P.C.	Washington University in St.Louis, Mo.

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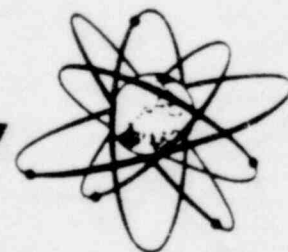
CSNI SPECIALIST MEETING  
ON  
**PLASTIC TEARING  
INSTABILITY**

St Louis, Miss. United States  
25-27 September 1979

Hosted by the  
CENTRE FOR FRACTURE MECHANICS  
Washington University, St Louis, Miss. USA  
and the  
UNITED STATES NUCLEAR REGULATORY COMMISSION

CALL FOR PAPERS  
AND  
ADVANCE INFORMATION

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**COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS  
OECD NUCLEAR ENERGY AGENCY**

38, boulevard Suchet 75016 Paris, France

CSNI Specialist Meeting on Plastic tearing instability;  
Washington University, St Louis (Miss) USA  
25th-27th September 1979

1. ORGANISERS, SPONSORSHIP

The Specialist Meeting on plastic tearing instability will be held at the Centre for Fracture Mechanics, Washington University, St Louis (Miss) USA, and is sponsored by the Committee on the Safety of Nuclear Installations (CSNI) of the OECD Nuclear Energy Agency. The meeting is hosted by the Centre for Fracture Mechanics and by the United States Nuclear Regulatory Commission.

2. BACKGROUND AND PURPOSE OF THE MEETING

The Committee on the Safety of Nuclear Installations maintains a Working Group to advise on specific safety aspects of steel components: the Group's activities fall within the three principal areas of fracture mechanics, welding and heat treatment, and non-destructive testing. In this context three specialist meetings have already been held on the general topic of steel-plastic fracture mechanics. In Brussels (1974), San Francisco (1976) and Jerezburg, United Kingdom (1978). The present meeting arose from a proposal made by the Working Group in 1978 to the effect that little or no international work had been done specifically with regard to tearing instability. Its purpose is to review recent developments and to provide CSNI, in the Proceedings, with a status report and specific recommendations as to areas where further work appears desirable.

3. PARTICIPANTS

The meeting is restricted and may be attended only upon nomination through delegates to CSNI in consultation with official authorities concerned.

P R O G R A M (Tentative)

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS (CSNI) SPECIALIST MEETING  
 OECD NUCLEAR ENERGY AGENCY, Paris, France  
 on

Plastic Tearing Instability

Hosted by the Center for Fracture Mechanics, Washington University in St. Louis  
 September 25, 26, 27, 1979

TUESDAY MORNING      THEORY AND GENERAL CONSIDERATIONS, A. Pellissier Tanon, Chairman  
September 25

- |     |                |   |  |
|-----|----------------|---|--|
| (1) | 9:00 - 9:45 AM | <u>J.W. Hutchinson</u>                                | "FOUNDATIONS OF TEARING INSTABILITY THEORY"  |
|     | 9:45 -10:00 AM | Discussion and<br>5-Minute Break                      |  |
| (2) | 10:00-10:25 AM | <u>W.H. Irvine</u>                                    | "PLASTIC TEARING INSTABILITY-WHAT IS IT?"<br>(Co-authored with A. Quirk)   |
|     | 10:25-10:30 AM | Discussion  |  |
|     | 10:30-11:00 AM | Break (with refreshments)                             |  |
| (3) | 11:00-11:25 AM | <u>A. Pineau</u>                                      | "STUDY OF INSTABILITY OF GROWING CRACKS USING<br>DAMAGE FUNCTION: APPLICATION TO WARM PRE-<br>STRESS EFFECT" (Authored by F.M. Beremin.) |
|     | 11:25-11:30 AM | Discussion  |  |
| (4) | 11:30-11:55 AM | <u>R. Denys</u>                                       | "GROSS STRAIN CONCEPT"<br>(Co-authored with W. Soete)  |
|     | 11:55-12:00 N  | Discussion  |  |
|     | 12:00-12:15 PM | Summary Points, <u>A. Pellissier Tanon</u> , Chairman |  |
|     | 12:15- 1:30 PM | Luncheon  |  |

TUESDAY AFTERNOON      THEORY AND GENERAL CONSIDERATIONS, J. Carlsson, Chairman  
SEPTEMBER 25

- |     |               |                                  |   |
|-----|---------------|----------------------------------|---|
| (5) | 1:30 -2:15 PM | <u>C. E. Turner</u>              | "REMARKS ON UNSTABLE DUCTILE CRACK GROWTH"  |
|     | 2:15 -2:30 PM | Discussion<br>and 5-minute Break |   |
| (6) | 2:30 -2:55 PM | <u>I. Milne</u>                  | "A TECHNIQUE FOR ANALYZING FRACTURE TOUGHNESS<br>TEST DATA DURING SLOW CRACK GROWTH"<br>(Co-authored with G.G. Chell) |
|     | 2:55 -3:00 PM | Discussion                       |   |
|     | 3:00 -3:30 PM | Break (with refreshments)        |   |

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TUESDAY AFTERNOON  
SEPTEMBER 25 (cont'd)

- (7) 3:30 - 3:55 PM      J.G. Merkle      "STABLE CRACK GROWTH ESTIMATES BASED ON EFFECTIVE CRACK LENGTH AND CRACK OPENING DISPLACEMENT"  
(Co-authored with C.E. Hudson.)
- 3:55 - 4:00 PM      Discussion
- (8) 4:00 - 4:25 PM      C.F. Shih      "AN ENGINEERING APPROACH FOR EXAMINING GROWTH AND STABILITY IN FLAWED STRUCTURES"
- 4:25 - 4:30 PM      Discussion
- 4:30 - 4:45 PM      Summary Points,      J. Carlsson, Chairman

WEDNESDAY MORNING  
SEPTEMBER 26

EXPERIMENTAL RESULTS C.E. Turner, Chairman

- (9) 9:00 - 9:45 AM      J. D. Landes      "SIZE AND GEOMETRY EFFECTS ON ELASTIC-PLASTIC FRACTURE CHARACTERIZATION"
- 9:45 -10:00 AM      Discussion  
and 5-minute break
- (10) 10:00 -10:25 AM      S.J. Garwood      "CRACK GROWTH RESISTANCE - GEOMETRY EFFECTS AND STRUCTURAL PREDICTIONS IN A533B Class I STEEL"
- 10:25 -10:30 AM      Discussion
- 10:30 -11:00 AM      Break (with refreshments)
- (11) 11:00 -11:25 AM      J. T. Gudas      "ISSUES IN DEVELOPING A PLANE STRAIN  $J_I$  CURVE TEST PROCEDURE"
- 11:25 -11:30 AM      Discussion      (Co-authored with J.A.Joyce and P.Albrecht)
- (12) 11:30 -11:55 AM      F. Loss      "J-R CURVE CHARACTERIZATION OF IRRADIATED NUCLEAR PRESSURE VESSEL STEELS"
- 11:55 -12:00 N      Discussion      (Co-authored with B.H. Menke, R.A.Gray, Jr. and J.R. Hawthorne)
- 12:00 -12:15 PM      Summary Points,      C.E. Turner, Chairman
- 12:15 - 1:30 PM      Luncheon

WEDNESDAY AFTERNOON  
SEPTEMBER 26

"EXPERIMENTS AND APPLICATIONS" E.T. Wessel, Chairman

- (13) 1:30 - 2:15 PM      A. Pellissier Tanon      "TESTING AND APPLICATIONS"
- 2:15 - 2:30 PM      Discussion and 5 minute break
- (14) 2:30 - 2:55 PM      T. Ingham      "THE MEASUREMENT OF DUCTILE CRACK INITIATION"
- 2:55 - 3:00 PM      Discussion
- 3:00 - 3:30 PM      Break (with refreshments)
- (15) 3:30 - 3:55 PM      R.L. Roche      "FORMULAS GIVING THE J-R CURVE FROM RESULTS OF ONE EXPERIMENTAL TEST"
- 3:55 - 4:00 PM      Discussion

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WEDNESDAY AFTERNOON  
SEPT. 26th/Cont'd

- (16) 4:00 - 4:25 PM                    G. G. Chell            "A SIMPLE METHOD FOR DETERMINING THE DUCTILE INSTABILITY OF CRACKED STRUCTURES" (Co-authored with I.Milne.)
- 4:25 - 4:30 PM                    Discussion
- 4:30 - 4:45 PM                    Summary Points, E.T. Wessel, Chairman

THURSDAY MORNING  
SEPT. 27th

APPLICATIONS

G.R. Irwin, Chairman

- (17) 9:00 - 9:45 AM                    P. C. Paris            FRACTURE PROOF DESIGN
- 9:45 - 10:00 AM                    Discussion and 5-minute break
- (18) 10:00 - 10:25 AM                J.L.Cheissoux        "CONDITION OF STABILITY OF AN AXIAL THROUGH CRACK APPEARING ON PWR SECONDARY PIPING IN REDUCED SCALE (1/10)
- 10:25 - 10:30 AM                    Discussion
- 10:30 - 11:00 AM                    Break (with refreshments)
- (19) 11:00 - 11:25 AM                B. Szabo              "AN ANALYSIS OF DUCTILE CRACK EXTENSION IN BWR FEEDWATER NOZZLES" (Co-authored with G.G.Musicco, M.P.Rossow)
- 11:25 - 11:30 AM                    Discussion
- (20) 11:30 - 11:55 AM                A. Zahoor             "A PRELIMINARY FRACTURE ANALYSIS ON THE INTEGRITY OF HSST INTERMEDIATE TEST VESSELS" (Co-authored with P.C.Paris and M.P.Gomez)
- 11:55 - 12:00 N                    Discussion
- 12:00 - 12:15 PM                    Summary Points        G. R. Irwin, Chairman
- 12:15 - 1:30 PM                    Luncheon

THURSDAY AFTERNOON  
SEPT. 27th

- 1:30 PM
- Conference Summary
- Recent work at Washington University
- Other Contributions

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It was agreed that Summary Statements would be limited to tearing instability and related analytical methods.

General

1. A single parameter can adequately characterize crack instability conditions and crack extension (growth).
2.  $J$  is the most general parameter for the above purpose
3. It is recognized that  $J$  can be related to COD and other parameters.

Initiation

1. The attendees agreed that it is appropriate to attempt to define a practical measurement point for crack extension, such as  $J_{IC}$ .
2. The approaches presented for determining the crack extension parameter are essentially the same.
3. The details and some limitations of measuring a practical extension point remain to be resolved.
4. The practical (engineering) point value is a measure of loading or deformation below which tearing instability is not expected. (There was considerable discussion about this point related to the complication of fracture mode change to cleavage.)

Growth

1. Stable crack growth can be characterized in terms of a single parameter (such as  $J$  or the  $J$ - $R$  curve), within limitations.
2. The limitations are those characterizations for plane strain which are associated with similarity of field conditions (in the vicinity of the crack tip) and with avoiding substantial amounts of unloading (such as Hutchinson's conditions for  $J$ -controlled growth).

3. Those characterizations apply uniformly from small-scale yielding through fully-plastic conditions, within limitations.
4. For structural steels, cleavage may intervene on the conditions for stable crack growth but currently is expected only in or near the fracture transition temperature range.

#### Instability of Tearing

1. The occurrence of tearing instability of cracks can be characterized through the use of the same parameter as that for describing growth (such as  $J_{\text{applied}}$  and the J-R curve).
2. The crack instability problem can be characterized as the occurrence of a tendency between the driving phenomenon and the material's resisting values of that parameter (such as  $J_{\text{applied}}$  becoming tangent to the J-R curve).
3. The several approaches to instability (such as energy-balance, J-tangency, etc.) are basically the same except for details or extrapolation beyond the recognized limitations.

#### Micromechanisms

1. It was agreed that the study of micromechanisms (such as the damage function approach and others) can enhance an understanding of fracture processes and of the limitations of current analyses.

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