Nuclear Regulation

The Nuclear Regulatory Challenge of Judging Safety Backfits

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996); Korea (12th December 1996) and the Slovak Republic (14th December 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of 27 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

FOREWORD

The Committee on Nuclear Regulatory Activities (CNRA) of the OECD Nuclear Energy Agency (NEA) is an international body made up of senior representatives from nuclear regulatory bodies. The Committee guides the NEA programme concerning the regulation, licensing and inspection of nuclear installations with respect to safety. It acts as a forum for the exchange of information and experience, and for the review of developments which could affect regulatory requirements.

In 1999, the Committee established a Task Group to reflect and advance the discussion on specific issues of regulatory policy. Over the years the Task Group produced a series of short reports dealing with early signs of declining safety performance and regulatory response strategies for safety culture problems, as well as the regulatory challenges arising from competition in electricity markets.

Continuing in the series, this report describes potential situations giving rise to safety backfit questions and discusses regulatory approaches for judging the backfits. The growing pressure on regulators to reduce the number of safety backfits is a challenge that many regulators currently face.

The present report was prepared by Dr. Thomas E. Murley, on the basis of discussion and input provided by the members of the Task Group listed below:

Dr. Michael CULLINGFORD (United States of America)
Mr. Lars GUNSELL (Sweden)
Mr. Jon JOHNSON (United States of America)
Dr. Klaus KOTTHOFF (Germany)
Dr. Annibal MARTIN (Spain)
Dr. Serge PRETRE (Chairman, Switzerland)
Mr. Philippe SAINT RAYMOND (France)
Mr. Lynn SUMMERS (United Kingdom)
Mr. Mike TAYLOR (Canada)
Dr. Gianni FRESCURA (OECD Nuclear Energy Agency)
Mr. Miroslav HREHOR (OECD Nuclear Energy Agency)

TABLE OF CONTENTS

1. INTRODUCTION

It is now generally recognised that the nuclear power programmes of OECD countries have reached a high level of maturity. A great deal of information and lessons have been learned from the several thousand reactor-years of operating experience and supporting research in OECD countries, and these lessons have become institutionalised in various national laws, regulations, nuclear plant operating procedures and nuclear plant programmes such as training, security, quality assurance and emergency planning.

A significant result of this operating experience has been the steady improvement in operational safety performance of nuclear power plants in OECD countries in recent years. This improved performance is reflected in many published performance indicators.

A parallel development in OECD countries is the trend to introduce competition in electricity markets.* The economic pressures of electricity market competition has led nuclear power plant operators to seek ways to increase electricity production and to reduce operating costs at their plants. Just as market competition produces competitive pressures on nuclear operators, there will be corresponding pressures on the regulatory bodies that include the demand to reduce regulatory burdens perceived as unnecessary and a general resistance by operators to consider safety backfits sought by the regulator. A frequently voiced demand by nuclear operators is the need for regulatory stability – that is, a stable set of regulatory safety requirements that the operator must meet and that are not changed frequently by the regulator. In other words, there is a growing pressure on regulators to reduce the number of safety backfits. This pressure will present a challenge to the regulator, which is the topic of this report.

---

* *Nuclear Regulatory Challenges Arising from Competition in Electricity Markets*, OECD/NEA, Paris, 2001.

Some countries have adopted the concept of a periodic safety review (PSR) for each nuclear power plant. A PSR gives the operator the responsibility to review the overall safety of the plant against current standards and to evaluate and justify any deviations. Experience in those countries has shown that operators generally have embraced PSRs because it allows potential backfit issues to be addressed in an integrated fashion and gives the operator the opportunity to put his safety case in an overall safety perspective.

The term backfit for dealing with new safety issues is intended to include a range of regulatory approaches. In countries where the approach is less prescriptive, with only the objectives being set by regulations, a new backfit issue is resolved through a process that includes discussions between the regulator and the operator, without formal changes in the regulatory requirements. In countries with a more prescriptive approach, after discussions between the regulator and operator, a backfit means a new or changed requirement by the regulatory authority to modify the operating conditions of a plant, to modify the systems, structures or components of a plant, to modify the programmes or procedures used to support operation of a plant, to modify the organisation used to support operation of the plant, or to modify the qualifications or training of safety workers at a plant.

While there are differences in the laws and regulations of each OECD country, all regulatory bodies set a level of safety that must be achieved by nuclear power plants. In the past four decades of commercial power operation, regulators have often required safety backfits, for a number of reasons. Among the reasons for requiring backfits are:

a) to maintain the required level of safety of a plant or plants;

b) to require compliance with existing regulations;

c) to require substantial safety enhancements when new information or analyses show that such enhancements are necessary and practical to implement.

Of course, there have been many instances where the nuclear plant operators, on their own initiative, have implemented backfits for the same reasons above. Some operators have adopted a policy of continuous improvement, which can also lead to operator-initiated backfits for improving safety. This continuous improvement policy focuses on regular self-assessments of safety performance and includes programmes for corrective actions, operating experience evaluation, and benchmarking against best practices in the nuclear industry. In some cases, new information has shown that safety margins were greater than believed, and that information has been used to relax some

safety requirements. While the focus of this report is on backfits (i.e. enhanced safety requirements), it should be kept in mind that the regulator may also consider requests for relaxation of safety requirements when new information or analyses justify such actions.

The large number of safety backfits over the years (as well as improved attention to safety management by operators) is believed to be a significant contributor to the improved safety performance of OECD plants over that period. However, neither operators nor regulators should allow improved performance to be a cause for complacency.

Regulatory bodies recognise that there are always arguments for and against backfitting, and they further recognise that operators wish to obtain regulatory stability. A stable regulatory environment does not mean, however, that there cannot be new safety backfits to nuclear plants. Clearly, when a new safety issue arises, whether from operating experience, new analyses, research programmes or other sources, the regulator has the responsibility to consider whether safety backfits may be required. A regulatory body should never stop looking for safety problems at nuclear power plants. Likewise, operators must acknowledge that they are responsible for operating their plants safely, and that includes the responsibility to consider safety backfits when new safety issues arise.

In view of the background above, the purpose of this report is to describe potential situations giving rise to safety backfit questions and to discuss regulatory approaches for judging safety backfits. It follows that the audience for this report is primarily nuclear regulators, although the information and ideas may also be of interest to nuclear operating organisations, other industry organisations and the general public.

2. SITUATIONS GIVING RISE TO SAFETY BACKFIT QUESTIONS

Making decisions on the need for safety backfits is a normal activity for any regulatory body, and all regulators can point to actual backfit decisions in the past. This section of the report describes some hypothetical situations that could give rise to safety backfit questions. Not every regulatory body would consider the following situations as posing backfit questions. Some regulators might consider the situations as involving normal regulatory actions to maintain the plant or plants within the approved safe operating envelope or the current design basis. In any case, the hypothetical examples are given to set the stage for the discussion of regulatory approaches for judging safety backfits.

Operating events

A routine inspection inside containment during an outage reveals evidence of small leakage of primary coolant water from a section of small bore piping. The operator proposes to conduct non-destructive examination of the full length of the pipe and to repair any cracks with a weld overlay technique. The regulatory staff believes all similar piping should be inspected and all cracked piping should be replaced.

Operating experience (conditions)

A routine design review reveals that under some accident conditions (unlikely but possible), the emergency diesel generators (EDGs) would be overloaded and therefore rendered inoperable. Adding an additional safety-grade EDG would be quite expensive, and the operator does not believe it is necessary for such an unlikely event.

Evolution in plant operating conditions

Some operators are proposing to increase the fuel burn-up limits for their plants. In reviewing these proposals, the regulatory staff believes that changes

in the fuel design may be needed, such as improvements in fuel assembly rigidity.

Evolution in nuclear plant technology

As nuclear plant component reliability increases, the relative weight of human factors in the residual risk increases. In reviewing this matter, the regulatory staff and the operator believe that safety can be improved by installing automated systems in place of relying on operator actions to cope with certain situations.

New insights from probabilistic safety analyses (PSA)

A plant-specific PSA shows that a large pipe rupture in the circulating water system could flood multiple rooms containing redundant safety system equipment. The regulatory staff acknowledges this is a new accident sequence not considered in the original safety licensing review but believes it should be corrected with new flood protection features. The operator believes that leak detection methods will allow actions to be taken to prevent a full pipe rupture.

Effects of plant ageing

A routine steam generator tube inspection finds indications of partial circumferential cracking. Comparison with previous tube inspection records shows the crack growth rate may be higher than expected. The regulator believes that another inspection should be conducted at the middle of the next operating cycle. The operator believes the inferred crack growth rate is an artefact of changed tube inspection methodology and that it is safe to wait until the next refuelling outage to do a tube inspection.

Inspection findings

During a comprehensive regulatory team inspection at an older plant it is found that the freeze protection system for the high pressure safety injection system is not single failure proof. Furthermore, the freeze protection system was not included in the original licensing basis as a safety-related system and is therefore not included in the technical specifications. The regulator is considering whether to require the addition of a redundant freeze protection

system and whether to add regular inspection requirements in the technical specifications.

New research findings

In a research experiment aimed at determining the best method for conducting tests on qualifying electrical equipment for the harsh environment inside containment during a loss-of-coolant accident, the researchers find that certain types of electrical equipment fail in 30% of the tests. The equipment suppliers and the operators contend that the tests are not representative of actual accident conditions.

New information external to the plant

During excavation for a construction project 10 km from a nuclear plant, a previously unknown seismic fault is discovered. The extent and severity of the ground fault is not known. Using new ground motion assumptions in seismic structural analyses, believed to be bounding assumptions, the regulatory staff finds that important safety systems may fail to function in an earthquake. The regulator and the operator are discussing how to determine the extent and severity of the ground fault and how to conduct new, realistic seismic analyses of the plant. Separately, the owners of the plant have let it be known that they are considering whether to shut down and decommission the plant if major backfits are required.

New international safety consensus (or standards)

After several years of research studies and analyses, safety experts gather at an international conference and conclude that the addition of new post-accident mitigation systems in containment can significantly reduce the offsite radiological consequences for certain core melt accident sequences. Regulatory bodies are pondering how to deal with this new consensus information.

New insights from periodic safety reviews (PSR)

A PSR finds that under certain conditions (unlikely but possible) a single failure in an electrical system could disable both trains of an important safety system. Both the regulator and the operator agree that the design should be changed but disagree on the urgency of installing the new design.

Safety reviews for plant life extension

During a safety review for an application for plant life extension, a detailed review of fracture toughness data from archival samples of pressure vessel welds reveals that the vessel weld material may not meet current requirements for weld fracture toughness.

International consensus on good safety practices

An international consensus has developed concerning the safety benefits of using plant-specific performance indicators (PIs) to track operational safety trends at each nuclear power plant. The regulator believes that the operator should implement a more comprehensive programme for collecting and publishing plant-specific PIs in conformance with this international consensus.

Summary

It is not the intent of this report to discuss the merits of any particular course of action for the hypothetical situations above. Rather, these examples are used to show that new safety information can come from a wide range of sources; that the initial information on safety significance may be fragmentary and inconclusive; and that there may be technical disagreements between the regulator and the operator on the facts of the situation and on the safety significance of the facts.

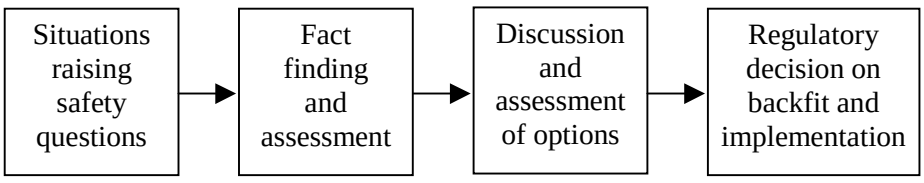
In situations like these, the regulator will be faced with the issues of whether to require a safety backfit and what should be an appropriate time period allowed to implement the backfit.

3. REGULATORY APPROACHES TO JUDGING SAFETY BACKFITS

When a situation arises like one of the examples above, where basic safety issues are apparent, both the regulator and the operator have a common interest in resolving the safety issues. While it is the responsibility of the operator to safely operate the nuclear power plant, the regulator has responsibility for independently assuring that all nuclear plants are operated safely. It is in the interest of safety that the regulator and the operator work together in a professional manner to establish the basic facts in the situation and to agree on a plan to develop the additional data and information that is needed.

The first question that must be asked in such situations is whether an immediate safety problem is present and whether urgent protective measures must be taken, such as the shutdown of the plant. This question of whether to take urgent protective measures may arise at any time during the backfit process. Experience has shown that most often the safety issues do not require urgent protective measures. If there is a difference of opinion on this matter, the regulator's views must prevail.

Whether or not immediate protective actions are taken, the broader question remains whether a backfit is required to address the safety issue and, if so, what is the appropriate backfit. The regulatory approach to judging safety backfits is based on the model shown below.



After the new information raising a safety issue has come into clear focus and a decision has been made on immediate protective actions, a period of fact finding will be needed to assess the scope of the safety issue. Are the physical

phenomena understood? Is more research or analysis needed? How many plants are affected? Do the plants meet the current regulations? Will new regulations, license conditions or regulatory guides be needed? Will safety be substantially improved by a backfit? Are there legal, regulatory credibility or other public policy issues that must be considered? The regulator may request the operator to perform special safety analyses, including probabilistic safety analyses (PSA). This phase of the process may take time, perhaps several months or a year or more, and of course there will be frequent discussions with plant management during this process.

As fact finding proceeds, the regulator and the operator will begin to form preliminary views on what is needed to resolve the safety issue. In some instances the operator may propose a voluntary backfit that is completely satisfactory to the regulator. In such cases, the regulator need do little more than formally document the backfit commitment and monitor its implementation through the regulatory inspection programme.

A more likely situation is that the regulator and operator do not initially have congruent views on the remedy for the safety issue. This situation will require discussions with plant management, and it is usually best for the regulator to request the operator to propose a remedy for the issue. If multiple options are under consideration, the operator may perform comparative analyses of the options.

After fully discussing the backfit options with plant management, the regulator must come to a decision on the type of safety backfit (if any) and the allowed time to implement the backfit. If the regulator concludes that a safety backfit is necessary to ensure the required level of safety, then the major remaining question is the time to implement the backfit. This judgment can usually be aided by insights from PSA as well as operating experience and an assessment of the robustness and effectiveness of the backfit.

In those cases where the required level of safety is not challenged, but where safety improvements are thought to be possible through a backfit, the regulator will balance the advantages and drawbacks of the proposed backfit. Some regulators may use a largely qualitative approach, considering such factors as the degree of improved safety, improved public confidence, or other factors. There may be considerations other than health and safety in deciding on backfits – for example, environmental protection, nuclear material security and compliance with international obligations such as non-proliferation objectives.

Other regulators may choose to use a more quantitative approach to judging backfits, such as the following two-part test:

a) the backfit must provide a substantial increase in safety;
b) the direct and indirect costs of implementing the backfit must be justified in view of the substantial increase in safety.

In judging whether a proposed backfit provides substantial additional safety protection, the analysis should follow established regulatory guidelines. One may use PSA for insights into quantitative benefits, for example the incremental reduction in core damage frequency resulting from implementation of the backfit. If the proposed backfit meets the first test of substantial increase in safety, the regulator may request cost-benefit information from the operator or may develop its own cost-benefit analysis. In evaluating whether the backfit benefits outweigh the costs, the analysis should include all costs associated with implementing the backfit – for example, design, procurement, installation, worker radiation exposure, procedure revision, training and costs for any plant shutdown time. Likewise, the benefits should include the reduced likelihood of accidents and their consequences (i.e. all averted costs including averted radiation exposure).

Whether the regulator uses a qualitative or quantitative approach, or some mixture of the two approaches, after reviewing the *pros* and *cons* of backfit options with the plant management the regulator must decide whether to impose the safety backfit.

If the decision is for a backfit, as mentioned above the regulator must also specify a time for completion of the backfit implementation, after discussions with the plant management. In some cases (e.g. steam generator tube inspections and tube plugging which are normally done during plant outages) the timing will be clear. In other cases involving design modifications and hardware changes, the practicalities of the design, procurement and installation processes will be major considerations in the implementation time, along with judgments of the safety importance of the backfit. A factor in the timing decision may be the use of compensatory actions while the backfit is being implemented.

After the decision on the backfit and implementation time have been communicated to the operator, the regulator should maintain a dialogue with the operator as the planning for the backfit progresses. In some cases, the regulator may want to review and approve any design changes to be sure that there are no unintended systems interactions or negative safety effects of the backfit.

The operator must review the design changes and bring the safety analysis reports, operating and maintenance procedures, training programme and other programmes into conformance with the backfit before it is actually implemented. Likewise, the regulator should ensure that the relevant regulatory guidance is revised, if necessary, to conform with the backfit decision. The regulator should plan to inspect the actual backfit implementation through the regulatory inspection programme.

As a conclusion to this regulatory approach for judging safety backfits, and in the spirit of improving regulatory performance, the regulator should consider conducting a retrospective self-assessment. Some of the questions that such a self-assessment could address are:

- Could the process for identifying new safety problems be improved?
- Was the fact-finding process concerning the new safety problem thorough?
- Were the interactions with the operator conducted professionally?
- Were communications with the public adequate?

4. SUMMARY AND CONCLUSIONS

While the operational safety performance of nuclear power plants in OECD countries has improved in recent years, neither operators nor regulators should allow that performance to be a cause for complacency. Regulatory authorities can still expect to be confronted with challenging safety backfit decisions from time to time. There will continue to be situations where operating experience or new information will give rise to safety issues and questions concerning the need for safety backfits. In this regard, regulatory bodies should continue to share essential safety information with their international colleagues.

This report discusses a general regulatory approach for judging safety backfits. The main features of this approach are the following:

- Regular analysis of plant operating experience, especially operational events, to determine whether new safety issues are presented.
- Regular review of the results of safety analyses (e.g. probabilistic safety analyses and periodic safety reviews) and research activities.
- A comprehensive fact-finding review of potential new safety issues.
- Frequent and thorough discussions with the operators on their view of the situation and on their proposals for addressing the safety issues.
- A careful analysis of the *pros* and *cons* of various backfit options.
- After the decision on a backfit and implementation time, monitoring the backfit implementation through the regulatory inspection programme.
- Revision of regulatory guidance, if necessary, to conform with the backfit decision.

A key principle of this approach is that the operators must maintain the responsibility for safely operating the nuclear power plants. In this regard, the regulator should preserve a dialogue with the operators to determine their views of the safety issues and their proposals for addressing them.

It is believed that the regulatory approach to judging safety backfits described in this report is consistent with the desire for a predictable and transparent regulatory process.

ALSO AVAILABLE

NEA Publications of General Interest

2001 *Annual Report* (2002) *Free: paper or web.*

NEA News
ISSN 1605-9581 Yearly subscription: € 37 US$ 45 GBP 26 ¥ 4 800

Geologic Disposal of Radioactive Waste in Perspective (2000)
ISBN 92-64-18425-2 Price: € 20 US$ 20 GBP 12 ¥ 2 050

Radioactive Waste Management Programmes in OECD/NEA Member Countries (1998)
ISBN 92-64-16033-7 Price: € 32 US$ 33 GBP 20 ¥ 4 150

Safety

Advanced Nuclear Reactor Safety Issues and Research Needs (2002)
ISBN 92-64-19781-8 Price: € 75 US$ 65 GBP 46 ¥ 8 700

Nuclear Fuel Safety Criteria Technical Review (2001)
ISBN 92-64-19687-0 Price: € 20 US$ 19 GBP 12 ¥ 1 900

Investing in Trust: Nuclear Regulators and the Public (2001)
ISBN 92-64-19314-6 Price: € 60 US$ 54 GBP 37 ¥ 6 050

Assuring Nuclear Safety Competence into the 21st Century (2000)
ISBN 92-64-18517-8 Price: € 55 US$ 50 GBP 31 ¥ 5 300

Collective Statement on Major Nuclear Safety Research Facilities and Programmes at Risk (2001)
Bilingual.
ISBN 92-64-08476-2 *Free: paper or web.*

Nuclear Safety Research in OECD Countries – Major Facilities and Programmes at Risk (2001)
ISBN 92-64-18468-6 *Free: paper or web.*

Nuclear Safety Research in OECD Countries – Summary Report of Major Facilities and Programmes at Risk (2001)
ISBN 92-64-18463-5 *Free: paper or web.*

Collective Statement on the Role of Research in a Nuclear Regulatory Context (2001)
Bilingual *Free: paper or web.*

Assuring Future Nuclear Safety Competencies – Specific Actions (2001)
ISBN 92-64-18462-7 *Free: paper or web.*

Improving Nuclear Regulatory Effectiveness (2001)
ISBN 92-64-18465-1 *Free: paper or web.*

Nuclear Regulatory Challenges Arising from Competition in Electricity Markets (2001)
Bilingual.
ISBN 92-64-08460-6 *Free: paper or web.*

Regulatory Response Strategies for Safety Culture Problems (2000)
Bilingual.
ISBN 92-64-07672-7 *Free: paper or web.*

Order form on reverse side.

ORDER FORM

OECD Nuclear Energy Agency, 12 boulevard des Iles,
F-92130 Issy-les-Moulineaux, France
Tel. 33 (0)1 45 24 10 15, Fax 33 (0)1 45 24 11 10

E-mail: nea@nea.fr**, Internet: http://www.nea.fr**

Qty	Title	ISBN	Price	Amount
		Total		

❑ Payment enclosed (cheque or money order payable to OECD Publications).

Charge my credit card ❑ VISA ❑ Mastercard ❑ American Express

(Prices include postage and handling fees).

Card No.	Expiration date	Signature
Name		
Address	Country	
Telephone	Fax	
E-mail		

The NEA wishes to express its gratitude to the Government of Japan
for facilitating the production of this report.

本報告書の作成に関し、日本政府の協力に謝意を表する。

OECD PUBLICATIONS, 2 rue André-Pascal, 75775 PARIS CEDEX 16
Printed in France.