Nuclear Safety
NEA/CSNI/R(2016)11
October 2016
www.oecd-nea.org

Results of the Questionnaire on Buried and Underground Tanks and Piping

OECD
BETTER POLICIES FOR BETTER LIVES

NEA
NUCLEAR ENERGY AGENCY

Unclassified **NEA/CSNI/R(2016)11**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

11-Oct-2016

English text only

NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

NEA/CSNI/R(2016)11
Unclassified

Results of Questionnaire on Buried and Underground Tanks and Piping

JT03402474

English text only

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 35 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the OECD.

OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 31 countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission 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;

– 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 the 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.

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of senior scientists and engineers with broad responsibilities for safety technology and research programmes, as well as representatives from regulatory authorities. It was created in 1973 to develop and co-ordinate the activities of the NEA concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations.

The committee's purpose is to foster international co-operation in nuclear safety among NEA member countries. The main tasks of the CSNI are to exchange technical information and to promote collaboration between research, development, engineering and regulatory organisations; to review operating experience and the state of knowledge on selected topics of nuclear safety technology and safety assessment; to initiate and conduct programmes to overcome discrepancies, develop improvements and reach consensus on technical issues; and to promote the co-ordination of work that serves to maintain competence in nuclear safety matters, including the establishment of joint undertakings.

The priority of the CSNI is on the safety of nuclear installations and the design and construction of new reactors and installations. For advanced reactor designs, the committee provides a forum for improving safety-related knowledge and a vehicle for joint research.

In implementing its programme, the CSNI establishes co-operative mechanisms with the NEA Committee on Nuclear Regulatory Activities (CNRA), which is responsible for issues concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also co-operates with other NEA Standing Technical Committees, as well as with key international organisations such as the International Atomic Energy Agency (IAEA), on matters of common interest.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report summarises the responses provided by the member organisations of the Working Group on Integrity and Ageing of Components and Structures (WGIAGE) of the Committee on the Safety of Nuclear Installations (CSNI) to a questionnaire on buried and underground tanks and piping (BTP) at commercial nuclear power plants. The questionnaire is comprised of twenty questions that address: operating experience; applicable codes and standards; the relevant regulatory framework; ongoing regulatory actions; the nuclear industry's responsibilities, plans, and actions within each country; and the technical and regulatory challenges. The principal objectives of this questionnaire are to gauge international interest in developing a database on BTP operating experience, identify information that could be contained in the database, share information on activities related to BTP, and identify possible areas for future collaboration. Responses were provided from representatives from seven countries as well as the Joint Research Centre (JRC) of the European Commission (EC).

Responses to the survey related to operating experience indicated that no BTP leaks in systems containing tritium were reported in most countries and only a small number of non-tritium BTP leaks were reported. The only tritium leaks reported between 2008 and 2012 were in the United States. Partly as a result of the small number of events, the interest in establishing a database of BTP leaks and failures is divided. While some respondents expressed interest, a more efficient path may be to capture these events as part of the existing OECD-sponsored Component Operational Experience Degradation and Ageing Programme (CODAP). The questions related to regulation and applicable codes and standards provide the following insights. Generally, the regulator charged with overseeing safety in the nuclear plants in each country is also the principal authority for safety-significant BTP systems. However, virtually all the countries identified other government or support organisations that also have some regulatory responsibilities related to BTP. A few countries have regulations that specifically address safety-related BTP. Most other countries also have broad regulations associated with pressure boundary or safety-significant components that may have limited applicability to BTP. While non-safety-related BTP is largely unregulated, most countries follow national and/or international commercial codes and standards for ageing management of BTP systems. There do not appear to be any significant gaps in any country's regulatory frameworks related to BTP. However, a few countries are addressing issues related to BTP at specific plants to determine whether any additional regulatory action is needed.

The responses did not identify any glaring or generic technical concerns associated with ageing management, leakage, and inspection of BTP. However, several technical issues were identified by the respondents including the improvement of 1) condition monitoring techniques, 2) design and accessibility of BTP, 3) mitigation and repair strategies, and 4) the understanding of important degradation mechanisms. Pitting and microbiologically induced corrosion were specifically mentioned as two degradation mechanisms of concern. In several countries, the regulator and nuclear industry are working together to address these issues by improving standards (e.g. Canada, Germany) or by assessing the condition of BTP (the Slovak Republic). In other countries (e.g. the Czech Republic, the Netherlands, the United States), the nuclear industry or the individual plant operators have the lead in addressing these issues while the regulator is monitoring and evaluating these efforts to determine if they are acceptable.

While these technical issues are being addressed, there are relatively few ongoing government-sponsored research activities associated with the resolution of these issues. Only the Slovak Republic indicated any ongoing activities. Several other countries have recently completed government-sponsored research on topics related to operating experience as well as detection, assessment, and consequences of degradation in BTP. However, commensurate with their responsibilities, the commitments and research activities that the nuclear industry is pursuing related to ageing management of BTP appear to be more extensive.

The nuclear industries in several countries, including the Czech Republic, Canada, the Netherlands, and the United States, are pursuing additional commitments related to ageing management of BTP. In particular, the US industry has developed a buried piping integrity initiative and supporting guidance that describes the goals and required actions of the nuclear power plant operators under this initiative. The US industry has also formed a Buried Piping Integrity Group to both oversee the implementation of this initiative and sponsor many different research activities related to non-destructive evaluation, ageing management, and assessment of BTP. Industries in several countries have joined this group as well.

No follow-on CAPS activities are recommended related to ageing management in buried, tanks, and piping because the issues do not appear to be widespread among enough countries to warrant broad follow-on efforts. The only action recommended for CSNI consideration is for the steering committee of the Component Operational Experience Degradation and Ageing Programme (CODAP) to assess the feasibility of tracking buried tanks and piping leakage and failure events as part of the scope of their activities. It is also recommended that the Project Review Group (PRG) of CODAP consider producing a topical report on buried tank and piping events and knowledge management activities.

These recommendations were discussed during the February 2016 CODAP PRG meeting. At this meeting, the PRG confirmed that BTP leaks and failures has been part of the CODAP scope since its inception, dating back to 2002. The CODAP National Co-ordinators have the ability to submit BTP events to the CODAP database. A topical report on buried tank and piping events and knowledge management activities is currently being developed under the CODAP Work Plan for 2015-2017.

LIST OF ABBREVIATION AND ACRONYMS

ASME	American Society of Mechanical Engineers
BP	Break preclusion
BfS	Bundesamt für Strahlenschutz (Federal Office for Radiation Protection, Germany)
BTP	Buried and underground tanks and piping
BWR	Boiling water reactor
CAPS	CSNI activity proposal sheet
CNSC	Canadian Nuclear Safety Commission
CNRA	Committee on Nuclear Regulatory Activities
CODAP	Component Operational Experience, Degradation and Ageing Programme
CODAP PRG	Program Review Group of CODAP
CSNI	Committee on the Safety of Nuclear Installations
DMW	Dissimilar metal welds
EC	European Commission
ECCS	Emergency core cooling system
ENSI	Swiss Federal Nuclear Safety Inspectorate
EPA	Environmental protection agency
EPR	European Pressurised Reactor
EPRI	Electricity Power Research Institute (USA)
ESW	Essential service water
DB	Design basis
DEC	Design extension condition
DEGB	Double-ended guillotine break
DID	Defence in depth
EQ	Environmental qualification
ET	Eddy-current testing
GTF	Groundwater task force
IAEA	International Atomic Energy Agency
IRSN	Institut de Radioprotection et de Sûreté Nucléaire (France)

JRC	Joint Research Centre
KFD	Kernfysische Dienst
LBB	Leak before break
LBLOCA	Large break LOCA
LOCA	Loss of coolant accidents
LTO	Long-term-operation
LWR	Light water reactor
MCL	Main coolant lines
MPA	Materialprüfungsanstalt (material testing laboratory)
MT	Magnetic Testing
ND	Nominal diameter
NDT	Non-destructive test
NEA	Nuclear Energy Agency
NRAJ	Nuclear Regulation Authority Japan
NRC	Nuclear Regulatory Commission
OECD	Organisation for Economic Co-operation and Development
OL3	Olkiluoto 3 (EPR-type reactor under construction in Finland)
OPDE	OECD Pipe Failure Data Exchange Project
POD	Probability of detection
PT	Penetrant testing
PWSCC	Primary water stress corrosion cracking
RCM	Risk control measures
RPV	Reactor pressure vessel
RT	Radiographic testing
SSC	Systems, Structures and Components
SSE	Safe shutdown earthquake
SSM	(Strålsäkerhetsmyndigheten) Swedish Radiation Safety Authority
TSO	Technical Support Organisation
TWC	Through-wall crack
UT	Ultrasonic testing
VT	Visual Testing
WGIAGE	Working Group on Integrity and Ageing of Components and Structures

1. INTRODUCTION

This activity was initiated as part of the CSNI Activity Proposal Sheet (CAPS) on long-term operation research that was approved in December, 2009. The CAPS was proposed and led by the Nuclear Regulatory Commission (NRC), which is the representative from the United States (US) to CSNI. The stated purpose of the CAPS is to identify technical areas of mutual interest related to age-related degradation of materials during long-term operation (LTO) of nuclear power plants (NPPs) and also capture operating experience associated with degradation in BTP.

The CAPS is comprised of a Phase I and a Phase II component. Phase I has two activities. The first activity is related to age-related degradation during LTO which is the focus of a separate questionnaire. The responses to the LTO questionnaire are summarised in a separate report (see attached reference list). The second activity is the proposed development of a database of international operating experience related to BTP events and issues. This activity was used as a trial for coordination among the member organisations on LTO issues that could be used to guide future collaboration on other LTO topics.

As a prelude to the development of the BTP database, a questionnaire was developed to assess the situation related to BTP issues within each country. The responses to this questionnaire are summarised in this report.

Phase II of the CAPS is intended to be a follow-on activity (or activities) that would be identified by the Phase I questionnaire responses where sufficient mutual interest exists for collaborative research on specific LTO topics. Recommendations for proceeding to Phase II for the LTO activity are provided in a separate report (see references). Phase II of the BTP activity is intended to extend and expand any BTP database on operating experience developed during Phase I. Recommendations for Phase II of the BTP activity are also provided in this report.

The remainder of this report summarises the background of the BTP issue which motivated this activity, the objective and scope of the BTP questionnaire, the questions addressed to each country, the responses from the organisations, and conclusions and recommendations for proceeding to Phase II of this effort as described in the CAPS on LTO. A relevant reference list is also provided by each country at the end of this report. Each organisation’s responses to the questionnaire are contained in the appendix.

2. BACKGROUND

In recent years, the inadvertent release of tritium to the environment from buried and underground piping at US NPPs has led to increased scrutiny of these components by the industry and the NRC. In 2006, US NPPs adopted the Nuclear Energy Institute Groundwater Protection Initiative (See attached references), which provides guidance on the development of groundwater protection programmes, stakeholder communications, and programme oversight.

Several well-publicised tritium leaks from buried piping in 2009 and 2010, however, resulted in groundwater contamination and increased the concerns associated with degradation of BTP as an increasing number of plants are operating beyond 40 years. Thus far, the leaks have not raised safety or regulatory compliance concerns or had significant effects on public health and safety. The US nuclear industry and NRC both agree, however, that leaks from BTP have the potential to become safety, radiological, environmental, and financial concerns. In this regard, it is in the interest of the public health and safety to develop comprehensive measures to address leakage from BTP to minimise the possibility of more significant events.

To address this issue, the NRC developed and initiated a buried piping action plan (See attached references) to collect relevant operating experience data; monitor activities on related codes, standards, and industry practices; and assess the need to enact changes to inspections and other regulatory requirements. While the thrust of this action plan focuses on obtaining information pertaining to US plants, it also directs that the US information be augmented by relevant international information obtained as part of the BTP activity under the CAPS on LTO.

The NRC also convened a separate Groundwater Task Force (GTF). The purpose of the GTF was to evaluate NRC actions related to buried piping leaks and determine whether those actions need to be augmented. The GTF final report (See attached references) contains the following related action items:

NRC staff should initiate dialogue with international regulators to discuss collaborative approaches for effective resolution of groundwater protection issues.

NRC staff should develop an approach to evaluate domestic and international modelling and monitoring activities

The BTP questionnaire and its responses are intended to address these actions while fulfilling the broader objective of sharing information and identifying possible collaborative opportunities related to BTP.

3. OBJECTIVES

The principal objectives of the BTP questionnaire are to gauge international interest in developing a database on BTP operating experience, identify information that could be contained in such a database, understand the regulatory framework associated with BTP; identify ongoing activities related to BTP; and identify possible areas for future collaboration. To achieve these objectives, the questionnaire addresses operating experience; applicable codes and standards; the relevant regulatory framework for BTP; ongoing regulatory actions; and existing technical and regulatory challenges. Additionally, because the principal responsibility for the integrity of BTP resides with the nuclear power plant owner, the nuclear industry's responsibilities, plans, and actions related to BTP are queried.

4. SCOPE

As indicated previously, the questionnaire is focused on collecting information related to leaks and failures in BTP, the applicable regulations and codes and standards for BTP, current technical and regulatory issues, and any actions being performed to address these issues. The scope of the questionnaire is intended to address all buried and underground tanks and piping that exist in the plant. This should include both safety grade and balance-of-plant structures, although the focus is safety-significant BTP. However, most of the responses focused on piping and it is not clear that issues associated with buried tanks have been addressed to the same degree by the respondents.

5. QUESTIONNAIRE

The questionnaire is comprised of twenty questions. In this section, each question will be presented and the intent of the question will be summarised along with any examples or other information provided to the respondents to clarify the question. The first four questions are associated with the operating experience related to BTP in each country and the interest in capturing this experience in a database.

1. Are you interested in developing a database of international events summarising tritium leakage in BTP?

This question is intended to gauge the interest of participating countries in creating a database of leaks and failures of BTP, with the primary focus being those systems containing tritium.

2. Do you have a mechanism (i.e. a reporting requirement, database, or regulatory procedure) to identify and track leakage events in BTP that have occurred over the last several years?

This question is intended to identify how countries are notified about leaks in BTP and how such events are catalogued and tracked within their regulatory framework.

3. Please summarise your country's most significant recent events (within the last 5 years) related to tritium leaks in BTP. Please include the following information in your synopsis of these events:

a) type of nuclear power plant
b) system where leakage occurred
c) size and configuration of piping that leaked
d) the degradation mechanism and/or root cause that resulted in leakage
e) the total amount (or the concentration) of tritium that leaked
f) the total amount (or concentration) and the type of other liquid that leaked (e.g. service water)
g) the method used to detect the leakage
h) the method (if any) used to mitigate the leakage

This question is intended to get an estimate of the international leaks and failures in BTP involving a release of tritium over the last five years. The detailed information requested for each event is meant to be representative of the type of information contained in a database of these events. A secondary objective with this particular question is to determine how easy it is to collect such information.

4. Has the number or frequency of leaks or reported degradation in BTP increased, decreased, or remained roughly the same over the last several years? If events have increased or decreased, please estimate the rate of increase or decrease.

This last question related to operating experience is intended to determine any trends related to BTP leakage and failure over the preceding five years.

The next two questions address codes and standards associated with the inspection of BTP in nuclear power plants (NPPs) and also the maintenance, management, and assessment of BTP to preclude leakage or degradation that may result in leakage. Applicable codes and standards could include those developed and maintained by industry, commercial, regional, national, and/or international bodies.

5. Which national or international codes and standards govern inspection of BTP? Please summarise the requirements associated with these codes and standards, including:

- **a) allowable inspection method**
- **b) inspection frequency**
- **c) acceptance criteria**
- **d) reporting requirements**

This question is intended to identify the inspection requirements for BTP by summarising the inspection method and frequency, the criteria used to determine whether the component is fit for service if indications of degradation are found during the inspection, and the requirements that the NPP has for reporting the results of the inspection to the regulatory authority.

6. Please identify any other national or international codes and standards that address the maintenance, management, assessment, or use of BTP that is associated with managing (or identifying) leakage (or degradation that may lead to leakage) in BTP. For each code or standard, please describe the relevant requirements.

This question is intended to identify codes and standards that are used to manage leakage or precursor degradation that may evolve into leakage other than those related to inspection requirements in question 5. Such codes and standards could address maintenance, assessment/evaluation, or mitigation activities.

The next group of five questions pertains to the regulatory framework that exists in each of the responding countries related to BTP as well as current activities. The roles and responsibilities of the authorities responsible for regulating BTP are also queried. Finally, each respondent is asked for a summary of any ongoing research related to managing or detecting leakage in BTP that is being sponsored by an organisation with regulatory oversight of BTP.

7. Does the regulatory authority have responsibilities associated with BTP systems or leakage in these systems? If so, please briefly summarise the authority's role and responsibilities.

This question is asked to understand the role of the nuclear regulatory authority with respect to the regulation of BTP systems. The regulator is expected to retain the principal authority for safety-significant BTP systems. However, other organisations may play a role in the regulation of non-safety significant BTP systems, especially those where leakage can travel outside the plant boundaries.

8. Please identify and summarise any national or international regulations that your country uses to govern aging management and inspection of BTP.

This question is intended to provide a high-level summary of the regulations governing the management and mitigation of degradation in BTP.

9. Please identify any other governing bodies that have regulatory responsibilities associated with BTP systems or leakage in these systems and briefly summarise their roles and responsibilities.

This question is a companion to question 7. If there are other government organisations that have some role in the regulation of BTP systems, it is asked that they be identified and their roles defined.

10. If both your organisation and any other governing bodies share regulatory responsibilities, please differentiate the roles and responsibilities among your organisation and the other governing bodies.

This question is a companion to both questions 7 and 9. The intent is to clarify the different roles and responsibilities if there are situations where more than one government organisation has regulatory responsibilities over BTP systems.

11. Please summarise any research that your organisation (or another government body with responsibilities identified in Question 9 above) is sponsoring related to managing or detecting leakage (or degradation) in BTP.

The final question in this section is used to identify government-sponsored research related to understanding or mitigating degradation or leakage in BTP systems. Research related to better inspection of BTP should also be identified.

The next set of two questions are intended to summarise the nuclear industry’s responsibilities for ageing management of BTP and also describe any initiatives that are ongoing or planned associated with providing assurance that the ageing management of BTP is acceptable. Any current research that is being sponsored by the nuclear industry that is supporting the ageing management of BTP is also intended to be captured.

12. Please summarise any other responsibilities that the nuclear industry in your country has related to aging management or inspection of BTP that are in addition to their responsibilities to satisfy applicable regulatory and codes/standards requirements. For example, a voluntary industry programme may exist to manage degradation in BTP that all the nuclear plants agree to enact.

This question is intended to identify any voluntary ageing management programmes that the industry may be using to address degradation in BTP. These are programmes that are not explicitly required by the regulations but have been enacted to further improve or optimise the management of degradation in these systems.

13. Please describe any plans or initiatives that your nuclear industry has enacted related either to ageing management or inspection of BTP. As part of this description, please include any research that is being conducted related to managing or detecting leakage (or degradation) in BTP.

This question arose primarily because the US industry has created a buried tanks and piping initiative which has been developing "best-practice" inspection and ageing management guidance. The US industry has been conducting research and has agreed to adhere to these initiatives as they are developed even though they are not regulatory requirements. This question attempts to identify if any similar initiatives are in place in other countries.

The final seven questions in the survey address technical and regulatory concerns associated with ageing management, leakage, and inspection of BTP. Questions are focused on summarising any technical or regulatory gaps and activities that are ongoing or planned to address any such gaps. There are also specific questions related to the accessibility of safety-related BTP, the use of cathodic protection in these systems, and the use of indirect inspection techniques.

14. Please summarise any technical issues and concerns that your organisation and country have related to ageing management, leakage, and inspection of BTP.

This question is intended to identify any technical gaps with existing aging management and/or inspection programmes being used to mitigate leakage in BTP.

15. Please summarise the plans and/or activities that are being conducted to address the technical issues and concerns identified in Question 14. As part of this summary, please identify, for each activity, if they are being sponsored and conducted by a government body or by the commercial nuclear industry.

This question is a companion to question 14 and asks each country to identify ongoing or planned activities that are being sponsored either by the government or the nuclear industry to address the gaps identified in question 14.

16. Are there safety-related buried or underground piping whose condition can only be assessed by excavation (safety-related pipes that do not contain tritium, such that degradation or leakage cannot be detected by groundwater monitoring)

This question is intended to determine the extent to which excavation is the only applicable means to evaluate degradation or leakage in BTP. The focus of the question is safety-related BTP because it is expected that many non-safety-significant BTP is only evaluated using excavation. However, responses that describe the situation for non-safety-significant BTP are also acceptable.

17. What types of indirect assessment techniques are required to be used in your country and how are the techniques credited (for example, guided wave, potential surveys, etc.)?

The intent of this question is to identify both the prevalence and the allowable (or required) types of indirect assessment techniques to assess degradation in BTP. Indirect techniques are those that do not visually assess degradation but monitor another property of the component (e.g. electrical resistivity, acoustic impedance) to infer such degradation. This question also asks to describe the credit that such techniques are given to demonstrate that applicable regulatory requirements are met.

18. Please indicate any applications or uses, if any, which require cathodic protection. If cathodic protection is used, please identify any requirements for surveying cathodic protection systems.

This question is intended to identify the prevalence of cathodic protection systems in mitigating corrosion in BTP. Additionally, this question asks respondent to describe any requirements associated with developing and monitoring such systems.

19. Please describe any potential gaps in your country's current regulations (or regulatory framework) that may need to be addressed to provide reasonable assurance that leakage from BTP will not pose a significant public health and safety concern.

This question is intended to identify any gaps associated with regulating BTP to prevent leakage or failure.

20. Please summarise your country's plans to address any regulatory gaps that may currently exist.

This question is a companion to question 19 and asks each country to identify ongoing or planned activities that are being sponsored either by the government or the nuclear industry to address the gaps identified in question 19.

6. SUMMARY OF RESPONSES

6.1 Operating experience and interest in database

Organisations representing seven countries and the Joint Research Council (JRC) responded to the questionnaire between 2012 and 2013. The organisations included the Canadian Nuclear Safety Commission (CNSC), Canada; the Nuclear Research Institute (UJV Rež), Czech Republic; Materiaprüfungsanstalt (MPA), Germany; Ministry of Environment and Transport, Department of Nuclear Safety, Security & Safeguards (KFD), the Netherlands; Nuclear Power Plant Research Institute (VUJE), Slovak Republic; Swiss Federal Nuclear Safety Inspectorate (ENSI), Switzerland; United States Nuclear Regulatory Commission (US NRC), United States; and, as mentioned, the JRC.

The first question seeks to determine the interest of participating countries in creating a database of leaks and failures of BTP, with the primary focus being those systems containing tritium. The response to this question was divided. Canada, the Czech Republic, the Netherlands and the Slovak Republic indicated that they would be interested in developing a database of tritium leaks in BTP. The JRC also expressed interest in developing a database but they also indicated that they could contribute no event data since they do not receive reports of such leaks from the European countries. Germany, Switzerland, and the United States expressed little interest in the development of a separate database to track tritium leakage. In particular, Germany indicated that such events could be added under ongoing international database exchange projects such as the OECD-sponsored Component Operational Experience, Degradation and Ageing Programme (CODAP). The US NRC also indicated that a similar database has already been established by the US industry and the need for a separate database with many of the same events is unclear. In light of these responses, there appears to be no compelling reason to formally recommend the development of a separate database of tritium leaks in BTP systems. If there is sufficient interest in separately capturing these events, countries should pursue it under the existing CODAP activity.

As a follow-up to the recommendations resulting from this question, the CODAP scope was reviewed to determine if BTP events could be included in the CODAP database. As indicated by the CODAP PRG, incorporating failure events from BTP has been part of the CODAP scope, and its predecessor database the OECD Pipe Failure Data Exchange Project (OPDE), since 2002. Therefore, the national coordinators from country participating in CODAP, and OPDE before that, should already be submitting these events. Therefore, as indicated by the response above it is not necessary to create a separate BTP database and CODAP can be relied on to accumulate this data. A forthcoming CODAP Topical Report on BTP operating experience will offer an opportunity to compare the BTP events in the database with those listed in this report under question 3.The second question asks each respondent to identify how their organisation is notified about leaks in BTP and how such events are catalogued and tracked within their regulatory framework. The question only focuses on leaks that have occurred during the last several years. No country has direct means to receive information related to BTP leaks unless a radioactive release has occurred as a result of the BTP leak. Canada and Switzerland have reporting requirements if the leak has occurred in a pressure boundary component (Canada) or safety-classified component (Switzerland). Both Germany and the Netherlands indicated that they require reporting only if the leak results in radioactive discharge, not including tritium.

Such events are also not reported to the US NRC, but the NRC has access to the INPO ICES database, which contains records of leaks from buried and underground piping. The information in this database is particularly comprehensive for leaks occurring since 2009. As a result of the general lack of reporting of these events to the regulatory organisation, it will be difficult to obtain and share information among countries. This difficulty provides another reason to not pursue the development of a database of BTP leaks.

The third question asks each participating organisation to summarise any tritium leaks that have occurred within the last 5 years in BTP to provide the type of information that would be contained in a database of such events and determine how easy it is to collect such information. The United States has identified six such events between 2008 and 2012. More detail on each of these results is provided in the appendix. Canada did not perform a significant review of CNSC records but did indicate that tritium leaks from BTP have not been a significant issue for CANDU plants to date. All of the other countries, and the JRC, indicated that there have been no tritium leaks in BTP with the last five years. The Slovak Republic reported a leak in a non-safety fire system pipe and also two leaks in essential service water (ESW) piping. The JRC reported that in 2010/2011 a buried aluminium pipe that supplies cooling water to the HFR reactor in Petten was leaking due to galvanic corrosion. However, no radionuclides were released into the environment from this leak.

The fourth question asks about the trends related to BTP leakage over the preceding five years. Because most countries reported no tritium leaks and only a small number of BTP leaks during this timeframe, it is not possible to assess international trends. There were enough BTP leaks (i.e. tritium and all other leaks) in the United States, however, during this time period to assess US trends. In 2009, there were 8 events. In 2010, there were 14 events. In 2011, there were 3 events, and in 2012 (at the time of the reporting) there were no events. Therefore, the number of events appeared to increase up to 2010 and has subsequently decreased since then. It should be noted, that it takes a period of time to properly catalo events, so these numbers are just estimates. In particular, the number of events from 2012 could still increase as data is entered.

6.2 Relevant codes and standards

The fifth question asks the country to identify applicable codes and standards that govern BTP inspection and asks to provide a summary of the inspection requirements, acceptance criteria if degradation is found, and reporting requirements. Several of the countries (e.g. Germany, Switzerland) indicated that safety-related BTP is governed by their countries regulations. In the United States, most aspects of BTP are unregulated except for periodic testing of Class 2 and 3 BTP which is required by the ASME code. In Canada, the industry largely follows commercial standards as required by government regulations. Most other countries, however, indicated that non-safety-related BTP is largely unregulated although commercial standards are followed (e.g. the Czech Republic, the Netherlands, the Slovak Republic). However, in the United States, a variety of national and international codes and standards are applicable to various aspects related to BTP and groundwater protection. See the appendix for a summary of the relevant codes and standards and any related regulatory requirements provided by several of the countries.

The sixth question asks respondents to identify codes and standards that are used to manage leakage or precursor degradation that may evolve into leakage other than those related to inspection requirements in question 5. A few countries (e.g. the Czech Republic, the Netherlands) responded that no other applicable codes (other than those in question 5) exist although, in the Czech Republic, the industry is developing a proposed buried piping programme. There are additional environmental or radiation protection ordinances that are also applicable in other countries such as Germany, Canada, Switzerland, and the United States. The United States in particular has a suite of commercial and industry standards that address various BTP issues. More detailed information related to other codes and standards is provided in the appendix.

6.3 Regulator framework and current activities

The seventh question addresses the roles and responsibilities of the nuclear regulatory authority associated with BTP and any leakage or failure events in these systems. Generally, the regulator in most countries is the principal authority for safety-significant BTP systems. This appears to specifically be the case in the Czech Republic, Switzerland, the Netherlands, and Germany. It appears that both Canada and the

United States have some additional regulatory authority related to either non-nuclear compliant systems (Canada) or if leaks exceed current radioactive effluent levels (United States). There are no regulatory responsibilities currently defined yet in the Slovak Republic.

The eighth question asks each respondent to provide a high-level summary of the regulations governing the ageing management and mitigation of degradation in BTP. Note that this question draws a distinction between regulations and code and standards which were addressed earlier in questions 5 and 6. Many of the countries (e.g. Canada, Switzerland, the Netherlands) provided information on the regulations supporting requirements for pressure boundary or safety-significant components; ageing management of systems, structures, and components; and plant maintenance. While more detail is found in the appendix, these regulations are generally broad and appear to have limited applicability to BTP, primarily because BTP does not contain tritium in these countries. Additionally, neither the Czech Republic nor the Slovak Republic currently have regulations in place addressing BTP. Only Germany and the United States appear to have regulations that specifically address BTP. Germany cited the Radiation Protection and German Reporting Ordinances as well as KTA-3211.4 which address, respectively, maintenance and testing for systems housing radioactive substances; event reporting; and inspection requirements for pressure retaining components outside the primary circuit. The United States has regulations that require ASME Code requirements be followed for design, inspection, testing, and repairing BTP. Additionally, regulations exist in the United States to limit radioactive effluents. Plants in the United States that apply for licence renewal are also required to demonstrate that they have effective ageing management programmes for BTP. NUREG-1801 provides an acceptable ageing management program for BTP for use within the licence renewal period.

The ninth question requests that respondents identify any other governing bodies that have regulatory responsibilities associated with BTP systems or leakage in these systems and summarise their roles and responsibilities. Virtually all the countries identified other organisations that have some regulatory responsibilities for BTP. Several countries identified higher level organisations which have the ultimate authority over nuclear facilities such as the Ministry of Environment (BMU) in Germany and Dutch Ministry of Economic Affairs, Agriculture, and Innovation in the Netherlands. Other countries identified supporting organisations that ensure that regulations are implemented appropriately by adhering to inspection, maintenance and repair requirements. In Switzerland, the Pressure Vessel Inspectorate carries out these responsibilities while in Canada, an Authorised Inspection Agency is designated by CNSC to fulfil such duties.

There are other parts of the governments in certain countries that may have some role in the regulation of BTP. Worker safety is the responsibility of the State Labour Inspection Office in the Czech Republic and they play a role if there is a situation affecting worker safety. The Environmental Protection Agency (EPA) in the United States and Bundesamt für Strahlenschutz – BfS (Federal Office for Radiation Protection, Germany) – are charged with protecting the people and the environment from damage caused by radiation. For example, the EPA in the United States establishes allowable limits for tritium concentration in drinking water. However, in the US, the NRC has the sole regulatory responsibility for BTP.

The tenth question is a companion to the prior question as well as question 7 and asks each country to clarify the roles and the responsibilities for situations where more than one government organisation has regulatory responsibilities over BTP systems. These roles and responsibilities have largely been identified in the responses to these prior questions, and they have been previously summarised in this report. Some additional clarification and detail is provided in the appendix in the responses to question 10.

The eleventh question asks each country to summarise any research that any government organisation with responsibilities for BTP as identified in questions 7 and 9 is sponsoring related to managing or detecting leakage/degradation in BTP. Most of the countries, including Canada, the Netherlands, Switzerland, Germany, the United States, the Czech Republic, and the JRC do not have any current research addressing leakage/degradation in BTP. However, the Czech Republic has performed several studies on short and long-term degradation in BTP over the last 10 years. Additionally, Germany has recently completed an evaluation of operating experience of safety-related service water systems. While the evaluation identified a few events in BTP, none resulted in tritium leakage.

The NRC has also sponsored research in the past related to detection and the consequences of degradation in BTP in the United States. The research is summarised in NUREG/CR-6876, "Risk-Informed Assessment of Degraded Buried Piping Systems in Nuclear Power Plants," which concludes that relatively high levels of general wall thinning due to general corrosion are required before structural integrity is challenged. Also, NUREG/CR-7029, "Lessons Learned in Detecting, Monitoring, Modelling and Remediating Radioactive Ground-Water Contamination," documents activities used to manage contamination issues.

It only appears that the Slovak Republic has active research programmes related to BTP. In 2010, they initiated a study of the condition of ESW piping. A technical survey on ESW pipes in the concrete block was carried out in 2013, and then again in 2015. They also performed a study to evaluate condition monitoring and replacement of BTP.

6.4 Industry responsibilities, plans, and initiatives

The next question focuses on responsibilities that the nuclear industry has related to ageing management or inspection of BTP in addition to their usual responsibilities to satisfy applicable regulatory requirements. This question is intended to identify any voluntary ageing management programmes that the industry may be using to address degradation in BTP. This question was posed because the US industry has developed an extensive buried piping integrity initiative over the course of several years that is documented in various letters to the NRC between 2009 and 2013 (see attached reference list). There is also an industry guidance document, Nuclear Energy Institute 09-14, "Guideline for the Management of Buried Piping Integrity," that describes a goals and required actions of a nuclear power plant operator under this initiative. There is also a companion Groundwater Protection Initiative which establishes expectations with respect to the discovery and reporting of groundwater contamination. All nuclear power plant operators have committed to follow this initiative. More specific information and references related to these initiatives and related US industry guidance is provided in the appendix.

The industry in several countries is pursuing additional commitments. The industry in the Czech Republic plans to enter the Electric Power Research Institute (EPRI) Buried Piping Integrity Group and follow similar good practices regarding BTP degradation management as have been adopted in the United States. In Canada, the industry is developing a standard for periodic inspection of balance-of-plant systems which will include BTP. In the Netherlands, the operator of the Borssele power plant has been asked by the regulator to generically address leakage from BTP and also evaluate the best practices for ageing management and inspection of BTP. The operator has also been asked to evaluate their existing program for soil sampling to determine if it is acceptable of if improvements are needed. The remainder of the responding countries, including Germany, the Slovak Republic, and Switzerland, were not aware of any additional industry commitments for managing ageing and inspecting buried tanks and piping.

The next question is related to the prior question and asks each country to describe any plans or initiatives that the nuclear industry has enacted related to ageing management or inspection of BTP. The respondents are also asked to discuss any research that is being conducted by their nuclear industry related to managing or detecting leakage (or degradation) in BTP. As mentioned previously, EPRI has established the Buried Piping Integrity Group for overseeing the US industry BTP initiative. This group is also sponsoring research through EPRI on risk ranking software, development and evaluation of remote inspection techniques; development of nondestructive evaluation techniques; and the design, maintenance, and evaluation of cathodic protection systems.

The nuclear operators in the Czech Republic have an ongoing voluntary initiative to summarise available codes and standards related to BTP and create a proposal for a BTP aging management program.

As part of the development of an inspection program for balance-of-plant systems in Canada, The CANDU Owners Group have issued report COG-09-4055, "NDE Methods for Buried Pipe: Review and Best-Practice Recommendations," which reviews several inspection methods and provides recommendations for additional research needed to support a CANDU inspection program. As in their response to question 11, the Slovak Republic summarised the initiative to evaluate the condition of ESW piping but provided some additional detail. The initial part of the effort is to summarise operating events, repair and replacement activities, and develop acceptable conditions to provide adequate reliability. Then, they evaluated the actual piping conditions at selected locations.

6.5 Technical and regulatory issues

The fourteenth question asks each respondent to summarise any technical issues or concerns that your organisation and country have related to ageing management, leakage, and inspection of BTP. There was surprisingly little commonalty in the response which implies that each country as a unique set of issues that they are addressing. Both Canada and the Slovak Republic indicated that condition monitoring methods should be improved. Also, Germany and Switzerland identified concerns with microbiologically induced corrosion (MIC) and pitting corrosion that can lead to small leaks that are difficult to detect in BTP. They both indicated that this corrosion is often due to degradation of the inner surface coating on the piping. Germany also indicated that these small leaks can lead to soil erosion surrounding the pipes which, in the worst case, could ultimately lead to a larger rupture.

Other than the preceding common responses, the remainder were unique. The Czech Republic has only minor concerns due to the design and accessibility of their BTP systems. The United States also did not identify any technical issues affecting safety and believe that the current inspection procedures, in concert with repair and replacement as needed, are adequate. Current issues in the United States are mainly the concern of the industry to develop ways to reducing the cost and improving the reliability of inspection and repair activities. The Netherlands has specific issues with degradation and settling of buried cooling water lines at the Borssele plant and the fact that the operator only performs maintenance after a leak has been detected and not proactively. The JRC raised the concern of the integrity of BTP beyond the original design life of 30 years or so as plants operate for longer periods. In concert with longer operation, the JRC would like to identify mitigation and repair strategies for BTP.

The next question asks for a summary of any activities, or plans for such activities, that are being conducted to address the technical issues and concerns identified in the previous question. Additionally, each country is asked to indicate if the government or industry is sponsoring and conducting each activity. Government participation in activities is occurring in Canada, the Slovak Republic, and Germany. As indicated in their response to question 12, the Canadian industry and government are developing a standard for inspecting balance-of-plant pressure boundary components to address their current issues. As indicated in their response to question 11, the Slovakian government is evaluating the condition of all relevant buried piping. They are also participating in testing of new BTP condition monitoring techniques. Germany has recently revised KTA standard 3211.4 to require both more in-service testing requirements and more systems, structures, and components (SSCs) that are subject to these requirements.

Other countries identified industry activities to address current issues. In both the Czech Republic and the Netherlands, the plant owners are addressed specific leakage issues that have occurred at their plants. Similarly, the Swiss utilities that are affected by BTP degradation have initiated special maintenance measures to ensure the integrity of non-safety-related BTP. The US industry, as led by EPRI, have a whole suite of activities related to buried piping condition assessment, ageing management, structural integrity assessment, leak detection, and nondestructive evaluation. An extensive list of reports associated with these activities and links to summary descriptions of these activities from 2011 and 2012 are provided in the appendix.

6.6 Excavation, indirect assessment, and cathodic protection

The sixteenth question is specifically to determine the extent to which excavation is the only applicable means to evaluate degradation or leakage in BTP. The focus of the question is safety-related BTP because it is presumed that many non-safety-significant BTP is only evaluated/inspection using excavation. Most of the countries have some safety-related piping which does not contain tritium and can only be inspected through excavation, including Canada, Germany, the Czech Republic, the Netherlands, Switzerland, and the United States. The Slovak Republic was the only respondent with no safety-related buried piping that does not contain tritium.

Canada indicated that some buried emergency core cooling piping exists and possibly some other systems meet this criteria. However, this is not expected to be a significant issue in Canada. Switzerland and Germany also indicated that a very limited number of such pipes exist. An example of such piping in Germany is safety-related service water piping. The Netherlands also has fire suppression system piping that meets this criteria. The United States indicated that some ASME Class 3 buried piping is safety-related and does not contain tritium.

The next question asks if there are indirect assessment techniques that are required to be used in the respondent's country and, if so, how are the techniques credited in the regulations. Canada, the Slovak Republic, and Switzerland have no specific regulatory requirements for indirect assessment techniques. The Swiss response also mentioned that all inspection methods for safety-related SSCs have to be qualified as per their regulations. The Netherlands listed a host of indirect techniques that are apparently employed by the licensee including deformation measurements, robotic inspections, salinometer surveys, and non-destructive testing. However, it is not clear which, if any, of these techniques are required by their regulations. Both Germany and the Czech Republic allow resistivity testing between the soil and piping for some systems (e.g. raw water piping in the Dukovany plant, Czech Republic).

The only indirect inspection requirement required in the United States is a system pressure or flow test as described in ASME Section XI, Article IWA-5244. These requirements exist for all plants in the United States. For plants in the licence renewal period, information regarding the use of indirect inspection techniques is contained in NUREG 1801, as amended by NRC interim staff guidance. While such guidance is not a requirement for plants in the licence renewal period, it does provide an acceptable way to manage degradation of BTP as required by the United States regulations. Finally, information on indirect techniques is contained in the nuclear industry's Underground Piping and Tanks Integrity Initiative. However, this information is not required by the NRC to satisfy any applicable regulations.

The eighteenth question asks specifically about applications using cathodic protection and any requirements for surveying cathodic protection systems. Most of the countries reported either very limited or no use of cathodic protection in BTP systems and indicated that few associated regulatory requirements exist. GRS (Germany) indicated that cathodic protection is used in buried parts of service water systems, but there are no corresponding regulatory requirements. Cathodic protection is used in the raw water inlet piping in the Mochovce plant (the Slovak Republic), but that the requirements for this system will be established after the system is reconstructed.

In Canada, CSA standard Z662 addresses cathodic protection and monitoring of BTP and it appears that Canada has the strongest requirements. There are no requirements for the use of cathodic protection systems in the United States. However, as with indirect inspection techniques, guidance is contained in NUREG 1801, as amended by NRC interim staff guidance. While such guidance is not a requirement for plants in the license renewal period, it does provide an acceptable way to manage degradation of BTP as required by the US regulations. Finally, information on cathodic protection is contained in the nuclear industry's Underground Piping and Tanks Integrity Initiative. However, as indicated previously, this information is not required by the NRC to satisfy any applicable regulations.

The final two questions ask each respondent to describe any potential gaps in your country's current regulations (or regulatory framework) that may need to be addressed to provide reasonable assurance that leakage from BTP will not pose a significant public health and safety concern (Question 19). The follow-on question (20) asks each respondent to describe plans to address any such regulatory gaps. Most of the respondents (i.e. the Slovak Republic, the Czech Republic, Germany, and the Netherlands) are not aware of any regulatory gaps.

As mentioned previously in the survey responses, CNSC (Canada) has indicated that there is limited oversight of balance-of-plant pressure boundary components, some of which are BTP. A new CSA standard is being developed that will govern inspection requirements for these components. Adherence to this standard will be incorporated into the operating licences of the plants.

ENSI in Switzerland is currently discussing a potential issue if leakage occurs in buried discharge piping. Currently, the water in such piping is allowed to be slightly contaminated which, due to dilution, meets the regulatory limits after it has been discharged into rivers. However, leakage into the surrounding soil may lead to unanticipated enrichment close to the discharge piping since there is no dilution with the outlet water. The Swiss are currently discussing this issue to determine if additional regulatory action is required, but they have no actions current planned to address this issue.

Finally, in the United States, it is recognised that degradation of BTP could, if left undiagnosed and uncorrected, lead to challenges to the leak tightness of systems containing licensed or environmentally hazardous materials, or could challenge piping system structural integrity. The industry is pursuing initiatives to address design, maintenance, monitoring, inspection, repair and ageing management of BTP. The industry also has an initiative to address groundwater protection to address discovery, reporting and remediation of events where radioactive material is inadvertently released into the groundwater.

The NRC is currently monitoring the implementation of the industry initiatives to determine if they are sufficient rather than embarking on a path to incorporate the initiative requirements into the regulatory framework. Therefore, there are currently no gaps in the US regulatory framework related to BTP. However, if at some future point in time the NRC determines that any of the initiatives are not being sufficiently implemented, then the potential need for a regulatory response would exist.

7. CONCLUSIONS

A questionnaire on issues related to buried and underground tanks and piping (BTP) at commercial nuclear power plants was provided to member organisations of the Working Group on Integrity and Ageing of Components and Structures (WGIAGE).of the Committee on the Safety of Nuclear Installations (CSNI). The principal objectives of this questionnaire are to gauge international interest in developing a database on BTP operating experience, identify information that could be contained in the database, share information on activities related to BTP, and identify possible areas for future collaboration.

The questionnaire is comprised of twenty questions that address operating experience; applicable codes and standards; the relevant regulatory framework; ongoing regulatory actions; the nuclear industry's responsibilities, plans, and actions within each country; and the technical and regulatory challenges. The scope of the questionnaire is intended to address all buried and underground tanks and piping that exist in the plant. This should include both safety grade and balance-of-plant structures, although the focus is safety-significant BTP. Responses were provided from representatives from 7 countries as well as the Joint Research Centre (JRC) of the European Commission (EC). However, most of the responses focused on issues associated with buried piping and it is not clear if those responses are also applicable to buried tanks. Conclusions drawn from the responses to each of the questions follow.

7.1 Operating experience and interest in database

The first four questions are associated with the operating experience related to BTP in each country including how events are reported to the regulatory authority and if there is interest in developing an international database of BTP events. Most countries reported no BTP leaks in systems containing tritium and only a small number of non-tritium BTP leaks. The only tritium leaks reported between 2008 and 2012 were in the United States. There were six such events. In the United States, it appears that all BTP leaks peaked in 2009 and 2010 and have been decreasing since. However, it's currently unclear how comprehensive the reporting of such events are to the regulators. Events in safety-significant BTP systems (e.g. cooling water or essential service water) and those accompanied by a radioactive release should be reported to regulators. However, non-radioactive leaks in non-safety-significant BTP systems are typically not directly reported to the regulator.

The interest in establishing a database of BTP leaks and failures is divided. While some countries and the JRC expressed interest, it was pointed out that these events could be tracked as part of the existing OECD-sponsored Component Operational Experience Degradation and Ageing Programme (CODAP). It is recommended that the CODAP steering committee assess the feasibility of tracking such events and possibly producing a topical report related to BTP leaks and failures. Such an activity would augment the information produced by this questionnaire.

7.2 Relevant codes and standards

The following two questions address codes and standards associated with the inspection of BTP in nuclear power plants (NPPs) and also the maintenance, management, and assessment of BTP to preclude leakage or degradation that may result in leakage. A few countries have regulations that specifically address safety-related BTP. Non-safety-related BTP is largely unregulated. However, most countries follow national and/or international commercial codes and standards for ageing management of BTP systems. Several countries also have adopted additional environmental or radiation protection ordinances for BTP.

7.3 Regulatory framework and current activities

The next group of five questions pertains to the regulatory framework that exists in each of the responding countries related to BTP and the roles and responsibilities of each authority. Respondents are also asked to summarise any ongoing government-sponsored research related to managing or detecting leakage in BTP. Generally, the regulator charged with overseeing safety in the nuclear plants in each country is also the principal authority for safety-significant BTP systems. Most countries have regulations associated with pressure boundary or safety-significant components. However, these regulations are broad and appear to have limited applicability to BTP. As mentioned previously, only a few countries (i.e. Germany, United States) appear to have regulations that specifically address BTP.

Virtually all the countries identified other government or support organisations that also have some regulatory responsibilities related to BTP. Several countries (e.g. Germany, the Netherlands) identified higher level organisations with the ultimate authority over nuclear facilities. Other countries (e.g, Canada, Switzerland) identified technical support organisations that ensure that regulations are appropriately implemented. Other facets related to BTP, such as worker safety and environmental protection, are identified as the province of other government organisations by some countries (e.g. Czech Republic, Germany, United States).

As far as current government-sponsored research activities, only the Slovak Republic indicated any ongoing activities. They completed a study to assess the condition of ESW piping and are currently undertaking repair and replacement activities of this piping at selected locations. However, several other countries, including the Czech Republic, Germany, and the United States have recently completed government-sponsored research on topics related to operating experience as well as detection, assessment, and consequences of degradation in BTP.

7.4 Industry responsibilities, plans and initiatives

The next set of two questions address the nuclear industry's responsibilities for ageing management of BTP and summarise any ongoing or planned initiatives and research associated with the ageing management of BTP. The nuclear industries in several countries, including the Czech Republic, Canada, the Netherlands, and United States, are pursuing additional commitments related to ageing management of BTP. The most extensive activities are occurring in the United States. The US industry has developed a buried piping integrity initiative and supporting guidance that describes the goals and required actions of the nuclear power plant operators under this initiative. Also, a Buried Piping Integrity Group has been formed to both oversee the implementation of this initiative and sponsor many different research activities related to nondestructive evaluation, ageing management, and assessment of BTP.

7.5 Technical and regulatory issues

The next several questions in the survey address technical and regulatory concerns associated with ageing management, leakage, and inspection of BTP. While there were no generic or common technical issues mentioned by the countries, the following issues were identified: improvement of condition monitoring, design and accessibility of BTP, mitigation and repair strategies, and degradation. Pitting and microbiologically induced corrosion were specifically mentioned as two degradation mechanisms of concern. In several countries, the regulator and nuclear industry are working together to address these issues by improving standards (e.g. Canada, Germany) or by assessing the condition of BTP (the Slovak Republic). In other countries (e.g. the Czech Republic, the Netherlands, the United States), the nuclear industry or the individual plant operators have the lead in addressing these issues while the regulator is monitoring and evaluating these efforts to determine if they are acceptable.

There do not appear to be any significant gaps in any country's regulatory frameworks related to BTP. However, a few countries are addressing specific issues to determine whether any additional regulatory action is needed. Canada is currently developing a new standard to improve inspection requirements for balance-of-plant pressure-boundary components, which includes some BTP. Switzerland is discussing whether leaks in buried discharge piping can lead to unacceptable levels of contamination. Finally, the United States is currently monitoring the implementation of the industry initiatives to determine if they are sufficient such that no additional regulatory actions are required.

7.6 Excavation, indirect assessment, and cathodic protection

There are also specific questions related to the inspection of safety-related BTP that does not contain tritium, the use of indirect inspection techniques, and the use of cathodic protection in BTP. Most countries have some safety-related piping which does not contain tritium and can only be inspected through excavation. Examples include emergency core cooling piping (Canada), service water piping (Germany), and fire suppression piping (the Netherlands).

Indirect techniques are those that do not visually assess degradation but monitor another property of the component (e.g. electrical resistivity, acoustic impedance) to infer such degradation. Most countries do not have any specific regulatory requirements associated with indirect assessment techniques. The only such requirement in the United States is a system pressure or flow test as described in ASME Code. However, plants in many countries are employing techniques such as resistivity testing (Germany, the Czech Republic, the United States) and other nondestructive testing methods (the Netherlands, the United States) that are allowed to demonstrate acceptable ageing management of these systems.

Finally, most countries reported either very limited or no use of cathodic protection in BTP systems and indicated that few associated regulatory requirements exist. However, as with indirect assessment techniques, several countries allow use of cathodic protection to demonstrate acceptable ageing management of BTP.

8. RECOMMENDATIONS

No follow-on CAPS activities are recommended related to aging management in buried, tanks, and piping because the issues do not appear to be widespread among enough countries to warrant broad follow-on efforts. While there are plant specific issues that some countries are addressing, the most significant generic issues have been experienced in the United States. However, leakage and failures have been decreasing in the United States since 2010 and the US industry has established significant initiatives, commitments, and research that are expected to be effective in managing degradation in buried tanks and piping systems.

The only action recommended for CSNI consideration is for the steering committee of the Component Operational Experience Degradation and Aging Programme (CODAP) to assess the feasibility of tracking buried tanks and piping leakage and failure events as part of the scope of their activities. It is also recommended that the steering committee consider producing a topical report on buried tank and piping events and knowledge management activities. However, it is recognised that inclusion of such events in the database, and consequently the development of a topical report, may be hindered by the fact that none of the regulators in participating countries has a direct means to receive information related to leaks or failures in buried tanks and piping unless a radioactive release has occurred as a result of the event.

These recommendations were discussed during the most recent CODAP meeting in 23-24 February 2016. It has been confirmed that BTP leaks and failures has been part of the CODAP scope since its inception, dating back to 2002. Therefore, national coordinators should already be submitting BTP events to the CODAP database. In 2014 the CODAP PRG established its 2015-2017 Work Plan, which included a prioritised list of topical reports. Buried tank and piping events and related knowledge management activities appeared in this list. Work is ongoing and the BTP Topical Report is scheduled for completion during the 4th quarter of 2016.

9. REFERENCE LIST

The following is a list of references with information related to buried and underground tanks and piping as supplied by each country.

United States

Results of Questionnaire on Long-Term Operation of Commercial Nuclear Power Plants, Nuclear Energy Agency, Committee on the Safety of Nuclear Installations, NEA/CSNI/R(2015)13.

Fertel, Marvin (Senior Vice President and Chief Nuclear Officer, Nuclear Energy Institute). Letter to Mr William F. Kane (Deputy Executive Director, Homeland Protection and Preparedness, US Nuclear Regulatory Commission). Subject: Industry Initiative on Groundwater Protection, 31 July 2006, US Nuclear Regulatory Commission Agencywide Documents Access and Management System (ADAMS) Accession number ML062260198.

Pietrangelo, Anthony (Senior Vice President and Chief Nuclear Officer, Nuclear Energy Institute). Letter to Mr R. William Borchardt (Executive Director for Operations, U.S. Nuclear Regulatory Commission). Subject: Industry Initiative on Buried Piping Integrity, 20 November 2009, US Nuclear Regulatory Commission Agencywide Documents Access and Management System (ADAMS) Accession number ML093350034 and attachment: “Proposed Buried Piping Integrity Initiative,” ADAMS Accession number ML093350035.

NEI 09-14, Rev 3, “Guideline for the Management of Underground Piping and Tank Integrity”, Nuclear Energy Institute, Washington DC, April 2013, US Nuclear Regulatory Commission Agencywide Documents Access and Management System (ADAMS) Accession number ML13130A322).

Recommendations for an Effective Program to Control the Degradation of Buried and Underground Piping and Tanks, EPRI Report No. 1016456, Electric Power Research Institute, Palo Alto, California, December 2008.

Buried Piping Action Plan, Revision 1, September 14, 2010, US Nuclear Regulatory Commission Agencywide Documents Access and Management System (ADAMS) Accession number ML102590171.

Groundwater Task Force Final Report, Nuclear Regulatory Commission, Washington, DC, US Nuclear Regulatory Commission Agencywide Documents Access and Management System (ADAMS) Accession number ML101740509.

Licence Renewal Interim Staff Guidance, LR-ISG-2015-01, Changes to Buried and Underground Piping and Tank Recommendations, US Nuclear Regulatory Commission Agencywide Documents Access and Management System (ADAMS) Accession number ML15125A377.

Canada

CNSC Regulatory Standard: Reporting Requirements for Operating Nuclear Power Plants, S-99, March 2003.

CAN/CSA-N285.0: General Requirements for Pressure Retaining Systems and Components, updated 2007.

CAN/ULC-S603-1992 Underground Steel Tanks.

CNSC Regulatory Document RD-334 Ageing Management of Nuclear Power Plants.

Czech Republic

ČSN EN 13480-3 Metallic industrial piping – Part 3: Design and calculation, 2012.

ČSN EN 13480-6 Metallic industrial piping – Part 6: Additional requirements for buried piping, 2012.

Germany

KTA 3211.4 (2013-11): Pressure and Activity Retaining Components of Systems Outside the Primary Circuit.

Netherlands

Dutch Nuclear Safety Standard NVR NSG-2.12.

KTA 1403 Alterungsmanagement in Kernkraftwerken, 11/2010.

NUREG 1801, Rev. 2 "Generic Ageing Lessons Learned (GALL), December 2010.

Slovak Republic

Slovenski Elektrarne, Ageing management program of essential service water pipelines, JE/NA-311.09-09 „s", SE, Bratislava (2015).

Switzerland

SR814.201, The Water Protection Ordinance

Guidelines ENSI-B06, Vessels and Piping classified as important to safety: Maintenance.

Guideline ENSI-B07, Vessels and piping classified as important to safety: Qualification of non-destructive testing.

SVTI-Festlegung NE-014 Rev. 6, Vessels and Piping classified as important to safety: Non-destructive Testing of Vessels and Piping.

APPENDIX: RESPONSES TO SURVEY ON BURIED AND UNDERGROUND TANKS AND PIPING – SUMMARISED BY QUESTION

The responses to this survey are intended to apply to all piping within the plant. The responses should address both safety grade piping and balance-of-plant piping, as applicable.

A. Operating experience

1. ***Are you interested in developing a database of international events summarising tritium leakage in BTP?***

   Czech Republic: Yes

   Canada: Yes

   Slovak Republic: Yes

   Switzerland: Only limited interest in developing a database of tritium leakage in BTP.

   Joint Research Center of the European Commission (JRC): Yes, but contribution can only be limited, since JRC has no overview or direct insight into the problem of tritium leaks of BTP of power reactors.

   Netherlands: Yes, for buried tanks and piping but not specifically for only tritium leakages

   Germany: In principle Germany is interested in international experience with tritium leakage in BTP. However, in our opinion, this can be provided by using existing international databases such as the CODAP event database being developed through the NEA.

   United States: No, not sure how database would be used and don't see a need at this time given databases already established by the US industry.

2. ***Do you have a mechanism (i.e. a reporting requirement, database, or regulatory procedure) to identify and track leakage events in BTP that have occurred over the last several years?***

   Czech Republic: Yes, there is monitoring equipment

   Canada: Not a formal mechanism specifically tailored to this task, but should be able to collect the data through a review of historical S-99 reports on the degradation of pressure-boundary components. This would be a labour intensive task, but we could potentially hire a summer student to work on it. (Please note that S-99 is a CNSC Regulatory Standard tiled "Reporting Requirements for Operating Nuclear Power Plants", http://www.nuclearsafety.gc.ca/pubs_catalogue/uploads/S99en.pdf).

   Slovak Republic: All leakage events on BTP safety-related components are reported to the regulator.

   Switzerland: All inspection results related to leakage events on safety classified components of BTP are to be reported by the Swiss NPP.

   JRC: No

Netherlands: In The Netherlands, the Borssele (KCB) Nuclear Power Plant (NPP) is the only operating plant. The operator of KCB takes soil samples in order to monitor the integrity of the plant concerning leakages of radioactive substances. This does not include tritium. A program for identifying and tracking of water leakages is in place for parts of the cooling water lines (see answers to questions 14, 15 and 17). In case that releases would be detected, the operator would have to report these events to the supervisor.

Germany: According to the German *Reporting Ordinance (AtSMV,)* events due to discharge of radioactive material, release of radioactive material, and contamination and carryover of radioactive material have to be reported if specified criteria are met.

United States: The NRC has access to the INPO ICES database which provides the ability to search for records of leaks from buried and underground piping in the U.S. The database contains information that becomes more comprehensive and complete as time increases, with an large increase in comprehensiveness starting in 2009. The database is proprietary.

3. ***Please summarise your country's most significant recent events (within the last 5 years) related to tritium leaks in BTP. Please include the following information in your synopsis of these events:***

   a. type of nuclear power plant
   b. system where leakage occurred
   c. size and configuration of piping that leaked
   d. the degradation mechanism and/or root cause that resulted in leakage
   e. the total amount (or the concentration) of tritium that leaked
   f. the total amount (or concentration) and the type of other liquid that leaked (e.g. service water)
   g. the method used to detect the leakage
   h. The method (if any) used to mitigate the leakage

Czech Republic: There is no tritium in buried pipes in both Czech NPPs.

Canada: Without carrying out a significant review of CNSC records we currently cannot make the summary for the following questions. However, based upon our experience, this has not been a significant issue for CANDU plants to date.

Slovak Republic: There is no tritium in buried piping in both NPPs in the Slovak Republic. The following leakage events have occurred in BTP over the last several years.

- A leakage was found only at non-safety relevant piping (fire water): that piping has been replaced for the new one which is made of plastic.
- Over the last two years two leakages were found on essential service water system (ESW) piping in Bohunice NPP. It was the degradation of the outer wall of the piping caused by with the long-term effect of humidity in the area of missing insulation.

Switzerland: There were no events related to tritium leaks within the last 5 years.

JRC:

- The HFR in Petten is a reactor used for research and medical isotope production.
- In 2010/2011 the HFR was shut down for a longer period for repair work on a buried pipe supplying the reactor with cooling water.
- The pipe is made of aluminium and showed significant signs of galvanic corrosion. The heavily degraded location was observed during a routine inspection of the HFR and by gas bubbles in the water emerging from this location. Although no radionuclides were released into the environment the heavily degraded section of the pipe was replaced.
- The pipe was uncovered and the heavily degraded section of the pipe was cut out from the remaining pipe sections. A new pipe section was inserted and welded to the neighbouring original sections.

Netherlands: No tritium leaks were reported during the last five years at the Borssele NPP, which is a PWR.

Germany: No events related to tritium leaks in BTP have been reported within the last 5 years.

United States: The US events from 2008 to 2012 that were publicly reported and which resulted in tritium leakage from buried or underground piping are summarised in the following table.

Plant	Tritium Conc. (pCi/l)	Estimated Date (M/Yr)	References[1]	Description
Brunswick	19M	12/10	EN46473, ML110190210	Buried condensate makeup line was the likely source of the tritiated water leak.
Hatch	6.8M	9/11	EN47305, ML11308A667	Leaking line at condensate storage tank was abandoned in place and new above ground line was installed.
Oyster Creek	102k	4/09	ML101240991	Leaks in 8 and 10 in condensate transfer lines resulted from corrosion due to defect in coating.
Oyster Creek	10.8M	8/09	ML101240991, EN45299	8 to 10 gpm leak in condensate transfer piping due to galvanic corrosion at wall penetration.
Quad Cities, Unit 1	7.5M	10/07	ML072890262, ML091410349, ML101380328	Leak in underground piping residual heat removal (RHR) suction line.
Vermont Yankee	2.5M	2/10	http:// healthvermont.gov/ enviro/rad/yankee/ tritium.aspx	Steam pipes inside the advanced off-gas (AOG) pipe tunnel were found to be badly corroded and leaking nuclear steam. The floor drain of this concrete tunnel was found to be clogged with construction debris and mud, which caused condensate from the steam pipes to pool inside the tunnel and leak out of a failed joint.

1. References starting with "ML" are ADAMS accession numbers and can be found at http://adams.nrc.gov/wba/ by entering in the accession number. References starting with "EN" are event notification numbers and can be found at: http://www.nrc.gov/reading-rm/doc-collections/event-status/ by entering in the event notification number.

4. Has the number or frequency of leaks or reported degradation in BTP increased, decreased, or remained roughly the same over the last several years? If events have increased or decreased, please estimate the rate of increase or decrease.

Czech Republic: Not applicable.

Canada: Without carrying out a significant review of CNSC records we currently cannot confirm this. However, based upon our experience, this has not been a significant issue for CANDU plants to date.

Slovak Republic: There have been some pitting issues in buried ESW piping in the Bohunice NPP. Degradation of the outer wall of the piping occurred as a result of the long-term effect of humidity in the area of damaged insulation. Pitting in the location of the damaged insulation was observed during inspection of the excavated pipes. Repair of these pipes started in 2015.

Switzerland: There have been some MIC and pitting issues in buried auxiliary cooling water piping.

JRC: Not applicable, because only one incident in one research reactor.

Netherlands: Not applicable because no tritium leaks were reported in BTP.

Germany: Not applicable because no tritium leaks were reported in BTP.

United States: Based on a US industry database, the number of significant leaks in BTP (not just tritium leaks, but all leaks) increased, then decreased, from 2009 until 2012. In 2009, there were 8 significant leakage events, in 2010 there were 14, in 2011 there were 3 and in 2012 there were none. However, it takes a period of time before events are properly catalogued, so the number of events may be revised periodically. In particular, the number of events in 2012 will likely increase as data is entered.

B. Relevant codes and standards

5. Which national or international codes and standards govern inspection of BTP? Please summarise the requirements associated with these codes and standards, including:

a. Allowable inspection methods

b. Inspection frequency

c. Acceptance criteria

d. Reporting requirements

Canada:

- Pressure-Boundary licence conditions in Power Reactor Operating Licence (PROL) impose the CSA N285.0 standard. According to this standard, buried piping cannot be used in piping classified as Nuclear Class 1, 2 or 3.
- For Class 6 piping (Non-Nuclear), buried pressure vessels and piping shall be designed to CSA B51 rules. According to this standard, piping and pressure vessels designed and installed for underground service, shall be provided with a means for placing it in position without damaging its protective coatings and shall be externally protected in accordance with CAN/ULC-S603.1, Section 4, unless an impressed-current system is employed.

- CSA standard B51 also specifies the inspection requirements on buried vessel and piping, and refers to CSA Z662 for the buried piping welding, catholically protecting, and monitoring.
- Buried piping and pressure vessels are cathodically protected by:
  - a sacrificial-type system, designed in accordance with CAN/ULC-S603.1, Appendix A;
  - an impressed-current system, using PACE Report No. 87-1 for design criteria; or
  - a system designed by a registered professional engineer accredited by NACE International.
- Other relevant standards:
  - CAN/ULC-S603-1992, "Underground Steel Tanks";
  - ULC-S615-1998, "Underground Reinforced Plastic Tanks";
  - ORD-C58.10-1992, "Underground Jacketed Steel Tanks";
  - ULC-S652-1993, "Tank Assemblies for Collection of Used Oil"; or
  - CAN/ULC-S603.1-1992, "Galvanic Corrosion Protection Systems for Underground Steel Tanks".

Allowable inspection methods

a. Inspection frequency

- Canadian Standards Association is currently drafting a standard which will govern requirements for periodic inspection of balance-of-plant pressure-boundary components.

b. Acceptance criteria

- In accordance with CSA standard B51, if part of a system has been buried or is otherwise inaccessible for inspection, the test pressure shall be held for 24 h and a recording chart shall be used. Any evidence of leakage shall be considered unacceptable.
- Canadian Standards Association is currently drafting a standard which will govern requirements for periodic inspection of balance-of-plant pressure-boundary components.

c. Reporting requirements

- Canadian Standards Association is currently drafting a standard which will govern requirements for periodic inspection of balance-of-plant pressure-boundary components.

Czech Republic:

- The State Office for Nuclear Safety has no reason to force utilities to run any inspection program or follow any procedures.
- However, utilities care about BP due to economic reasons. BP inspections mostly follow Czech norm ČSN EN 13480-3 “Metallic industrial piping - Part 3: Design and calculation” and ČSN EN 13480-6 “Metallic industrial piping - Part 6: Additional requirements for buried piping”. Both standards are not nuclear specific.

a. Due to reasons mentioned above there are is not a list of allowed methods.

b. Inspection frequency differs on various piping systems. Some of them are inspected when there is an opportunity (e.g. when excavated for other reasons). Some of them (e.g. ESW piping) is accessed once in eight years through manholes and visually inspected from inner side.

c. To my current knowledge only “soft” criteria are used: visual examination and ultrasound measurement at suspected places.

d. There are no reporting requirements due to reasons mentioned above.

- Requested information is not summarised within a formal BTP program. Collecting such information would require extensive survey at both utilities.

Slovak Republic: Buried piping is not regularly monitored. The Nuclear Regulatory Authority of the Slovak Republic has no reason to force utilities to conduct any inspection program or follow any related procedures. However, buried piping is a concern for the utility. The ESW system was inspected using the georadar method in sections where pipes are buried and located in concrete block. Inspections were also performed using excavation at selected ESW locations after leakages were observed at the pipes that are buried in the soil. Both visual and ultrasonic methods were also used to inspect the ESW piping.

Switzerland:

- Guidelines NE-14 and ENSI-B06 define the scope and frequency of inspection and maintenance work to be performed on nuclear safety classified components (safety classes 1 to 4).
- Depending on the safety classification the inspection interval is in a range between 4 and 16 years. All applied inspection methods have to be qualified according to ENSI-B07 including a performance demonstration based on realistic flaws scenarios (e.g. pitting, MIC, SCC).
- There are no specific nuclear codes and standards related to BTP in Switzerland, see below.

JRC: Unknown

Netherlands: The Inservice-Inspection program is based on the Dutch Nuclear Safety Guide NVR-2.2.2, the 1986 ASME XI Code, and national regulations concerning steam and pressure equipment. However the BTP are not part of the ISI-program. The inspections of BTP are covered by civil engineering codes.

Germany: There are no specific nuclear codes and standards for BTP inspection.

- However, inspection of safety-related BTP is governed by KTA-3211.4.
- According to KTA-3211.4, for buried pipelines the following applies:
  - When selecting representative locations for examination, those locations shall be considered which are subject to higher stresses induced by level D-type loading, e.g. at building penetrations.
  - The selected visual examinations of the outer surface may be replaced by an examination from the inner surface. The test procedures/techniques to be applied shall be identified for each individual plant.

a. Allowable inspection methods according to *KTA-3211.4*:

i. surfaces: Ultrasonic testing (UT), Magnetic Testing (MT), Penetrant Testing (PT), Radiographic Testing (RT), Eddy-Current Testing (ET), Visual Testing (VT)

ii. wall thickness: UT, RT

iii. general condition: plant inspection

iv. Other pressure test.

b. Inspection frequency:

– Vessels

i. Examination of surfaces with MT or PT or UT or RT or ET: 4 years (4a)

ii. Examination of surfaces with VT selective: 4a

iii. Pressure test: 8 years (8a)

– Ferritic pipes (DN ≥ 50):

i. Examination of surfaces with MT or PT or UT or RT or ET: 8a

ii. Examination of surfaces with VT selective: 8a

iii. Examination for wall thickness reduction with UT or RT: Extent and interval of the tests shall be specified in a test instruction

– Austenitic pipes (DN ≥ 50):

i. Examination of surfaces with PT or UT or RT or ET: 8a

ii. Examination of surfaces with VT selective: 8a

c. Acceptance criteria:

– MT, PT: acceptance level shall be considered to be exceeded if indications

i. are deemed to be attributable to planar flaws,

ii. show a linear dimension of more than 10 mm or

iii. for components made of austenitic steels, indicate linear dimensions exceeding 3 mm that are deemed to be attributable to corrosion.

iv. for fields of indication (i.e. an area containing accumulated linear indications), the acceptance level will be exceeded if conclusion can be drawn that the indications are due to operational defects, e.g. corrosion

– Ultrasonic testing (UT): The acceptance level shall be considered to be exceeded if

i. the echo amplitudes of the indications exceed the recording limit by 6 dB or more or

ii. the echo amplitudes of the indications reach or exceed the recording limit and show a linear dimension exceeding

▪ 10 mm in the case of wall thicknesses less than 20 mm

- half the nominal wall thickness in the case of wall thicknesses ≥ 20 mm in which case the linear dimension shall be determined by means of the half-value method; or

v. the echo amplitude of an indication not yet documented reaches or exceeds the recording limit and this indication cannot be explained by tolerances due to the test technique employed or when fixing a new recording limit if an equivalent test method is applied, or

  – RT: acceptance level exceeded if the indications suggest the presence of crack-like defects or incomplete fusions as well as wall thinning due to corrosion.

  – ET: The acceptance level is deemed to be exceeded if

vi. the amplitudes of the eddy-current signals exceed the recording level by 6 dB or more and their phase is located in the phase analysis range,

vii. the amplitudes of the eddy-current signals reach or exceed the recording level, their phase is located in the analysis range and

  - the patterns suggest a planar flaw or if the signal length exceeds
  - 10 mm if the wall thickness is less than 20 mm
  - half of the nominal wall thickness if the wall thickness is 20 mm or greater in which case the linear dimension is to be determined to the half-value method.

– VT: Conspicuous indications found by visual examination shall be treated as relevant indications which require

i. measures for restoring the proper condition (e.g. leakage, cracks) or

ii. measures for a more detailed assessment to demonstrate acceptability.

d. Reporting requirements:

  – According to criterion N 2.2.1 of the German Reporting Ordinance (AtSMV), any deformation or falling below the nominal wall thickness of safety-related components has to be reported.
  – Usually N 2.2.1 is interpreted in the way that wall thinning or cracking is to be reported at the latest when the required calculated wall thickness according to the specifications is not met or if the indication position and extent indicate a systematic problem.

United States:

- Variety of national and international codes and standards are applicable to various aspects related to buried and underground piping and groundwater protection. For example, NACE has issued standards related to the design, inspection, maintenance, repair and cathodic protection of underground piping. Licensees may voluntarily follow these standards, or may commit to follow these standards via the industry initiative process.

- For required inspections, the only standards invoked as requirements are the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Inservice-Inspection. The only applicable standard is IWA-5244, which requires periodic pressure or flow testing. The allowable inspection methods include visual test for leakage, system pressure tests and unimpeded flow tests.

- For Class 2 and 3 buried piping, a system leakage test is required to be performed every inspection period. The acceptance standard is established by the owner. If the system is non-isolable, then an unimpeded flow test may be performed.

- Reporting is not required except as required for repair replacement activities.

- The Code of Federal regulations requires reporting of leaks where certain limits of radiological activity are exceeded. In practice, buried and underground piping leaks have not resulted in releases of radioactive material that exceed a small fraction of the reportable limits.

6. Please identify any other national or international codes and standards that address the maintenance, management, assessment, or use of BTP that is associated with managing (or identifying) leakage (or degradation that may lead to leakage) in BTP. For each code or standard, please describe the relevant requirements.

Canada: "Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products" Please Part 6 of the standard for details. (http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=61B26EE8-1&offset=10&toc=show).

Slovak Republic: See answer to question 5. Buried piping does not contain tritium. The ESW system has been identified as the most important BTP system. A project to repair and replace some ESW piping sections is currently ongoing. This activity is being driven by the utility and is being monitored by the regulator. A systematic BP program which would summarise available codes and standards has not been established yet.

Switzerland: The Water Protection Ordinance (Gewässerschutzverordnung, SR814.201) defines the following requirements for toxic fluids (limited to storage facilities for which it needs a permit):

- Visual inspection of the inner surface of buried single-wall steel tanks and pipes has to be performed every 10 years.

- Leak detection systems for double-walled tanks and pipes have to be checked every two years, for single-walled tanks and pipes they have to be checked annually.

JRC: Unknown

Czech Republic: See answer to question 5. Moreover there is an ongoing project on BP, which summarises available codes and standards including United States ones, to create a proposal for a BP program for Czech NPPs. This activity is operator driven and is not requested by authorities. The list of applicable standards will probably change in near future, but work is still in progress.

Netherlands: Not applicable

Germany: According to the German *Radiation Protection Ordinance* the following applies:

- The competent authority may stipulate that the integrity and leak tightness of the casing for enclosed radioactive substances whose activity exceeds specified limits be inspected adequately and that the inspections shall be repeated at specified time intervals. For high-activity radiation sources, the inspection shall be performed at least once a year, unless the competent authority prescribes another time interval. These requirements shall not apply to enclosed radioactive substances delivered as radioactive waste.

- If the casing of enclosed radioactive substances or the device into which they are inserted is mechanically damaged or corroded, it shall be ordered that, prior to further use, the casing of the enclosed radioactive substance is inspected for leak tightness by a professional expert.

United States: There are a variety of standards and codes that address various aspects issues related to buried piping. Organisations that sponsor relevant codes and standards include ASME Section III and XI, NACE International, the Steel Structures Painting Council, and the American Society for Testing and Materials, the American Concrete Institute, the American Petroleum Institute, the American Water Works Association and the Pipeline Research Council. The reader is referred to the standards organisations for descriptions of these codes and standards.

C. Regulatory framework and actions

7. Does the regulatory authority have responsibilities associated with BTP systems or leakage in these systems? If so, please briefly summarise the authority's role and responsibilities.

Czech Republic: Regulatory responsibility is limited to safety-related piping, which includes only ESW.

Canada:

- Oversight of CSA Standard B51 compliant systems
- Periodic Inspection and review of pressure-boundary degradation reports submitted in accordance with Regulatory Document S-99.

Slovak Republic: Regulatory responsibility is limited to safety-related piping, which includes only ESW systems.

Switzerland: ENSI is responsible for the regulatory oversight of all safety relevant nuclear SSCs. Only a very limited number of BTP belongs to this category.

JRC: Not applicable

Netherlands:

- The Kernfysische Dienst (KFD) is part of the Inspectorate of the Dutch Ministry of Infrastructure and the Environment and is responsible for the supervision on nuclear facilities (e.g. supervision of inservice-inspection of tanks and piping performed by the operator, design review of modifications of BTP applied for by the licence holder).
- This includes the supervision associated with BTP related to nuclear safety in the power plant of Borssele.
- KFD is furthermore responsible for reporting of incidents to the Dutch Parliament. Licensing and regulation is in the responsibility of the Ministry of Economic Affairs, Agriculture & Innovation

Germany:

- The individual states are responsible for the supervision and surveillance of nuclear facilities including all safety relevant nuclear SSCs such as BTP.
- The BMUB (Ministry for the Environment) exercises federal supervision of the states and ensures that safety principles and requirements are applied in a uniform manner.
- Reportable events (i. e. on BTP) will be submitted by the nuclear facility operators to their responsible state authority, which will then pass this information to the BMUB and the incident registration centre operated by the Federal Office for Radiation Protection (BfS) and to the experts appointed by the BMUB, the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS).
- GRS as German TSO evaluates (leakage) events in BTP on behalf of BMUB

United States:

- For all nuclear power plants, the regulations in Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix A, “General Design Criteria,” or similar requirements imposed during plant licensing for pre-10 CFR Part 50 Appendix A facilities, and 10 CFR 50.55a, “Codes and Standards,” provide design requirements for safety-related components, including some buried piping. In addition, 10 CFR 50.55a provides requirements for examining and testing buried, safety-related piping.
- Licensees are required to verify that radioactive effluents, either from pipe leakage or from normal operations, are within NRC regulatory limits and design objectives. The NRC limits for radioactive effluents are contained in 10 CFR 20.1301, "Dose Limits for Individual Members of the Public," and the design objectives are contained in 10 CFR 50 Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion ‘As Low as is Reasonably Achievable’ for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents." These limits and design objectives are incorporated into licensee’s technical specifications and Offsite Dose Calculation Manual.
- For new plants where license applications are submitted after August 20, 1997, 10 CFR 20.1406 “Minimisation of Contamination” requires a description of how the facility's design and procedures for operation will minimise (to the extent practicable) contamination of the facility and environment, facilitate decommissioning, and minimise the generation of radioactive waste.
- For plants applying to renew their licences, 10 CFR Part 54, “Requirements for Renewal of Operating Licences for Nuclear Power Plants,” establishes requirements for managing ageing effects of certain systems and components, including buried piping, that are important to safety or whose failure could adversely impact the ability of systems to perform their intended safety function.
- With regard to buried piping, the goals of current regulations are to ensure that the piping is able to perform its intended safety function by supplying sufficient fluid flow and to maintain inadvertent releases below licensee’s technical specifications or other applicable limits.

8. ***Please identify and summarise any national or international regulations that your country uses to govern aging management and inspection of BTP*.**

Czech Republic: There are currently no regulations in place.

Canada:

- CNSC Regulatory Document S-210 addresses general requirements for plant maintenance programmes, including inspection.
- CNSC Regulatory Document S-99 contains requirements for reporting pressure-boundary degradation issues.
- The requirements for ageing management (AM) of NPP are set out in CNSC Regulatory Document RD-334 “Ageing Management of Nuclear Power Plants”.

Slovak Republic: No tests – which are established by the standard – were done, i.e. other governing bodies are not involved. (i.e. there are none).

Switzerland:

- Guideline ENSI-B01 defines requirements for ageing management. The scope of ENSI-B01 covers SCC of safety classes 1 to 3 and selected additional components identified by probabilistic criteria (PSA).
- The scope of ENSI-B01 includes some buried pipes (safety-related pipes that do not contain tritium).

JRC: Not applicable

Netherlands:

- Ageing management is generally addressed in the Dutch Nuclear Safety Standard NVR NSG-2.12.
- Additional guidance on Nuclear Safety Standards for Long-Term-Operation is provided from IAEA documents. The licence holder of KCB will apply the IAEA Safety Report No. 57 “Safe Long-Term-Operation of Nuclear Power Plants (SR57)” and the IAEA Safety Guide No. NS-G-2.12 “Ageing management for Nuclear Power Plants” in his the long-term operation project.
- Furthermore the licence holder of the NPP Borssele is intending to apply the following sets of nuclear standards in the recently started 3rd PSR of the power plant concerning the PSR safety factor 4 (ageing management). The set of nuclear standards to be addressed within the PSR will be assessed by the Dutch Ministry of Economic Affairs, Agriculture & Innovation (see answer to question 9) in beginning of 2012 and the following table is therefore to be seen as preliminary (It was discussed with the licence holder to consider additionally KTA 1403 “Alterungsmanagement in Kernkraftwerken, 11/2010” and NUREG 1801, Rev. 2 “Generic Ageing Lessons Learned (GALL), december 2010”.).

NVR	NS-R-1	Safety of Nuclear Power Plants: Design	2000
NVR	NS-R-2	Safety of Nuclear Power Plants: Operation	2000
NVR	NS-G-2.12	Ageing Management for Nuclear Power Plants	2009
IAEA	SF-1	Fundamental Safety Principles	2006
WENRA	RL I	Ageing management	2008
WENRA	RL K	Maintenance, in-service inspection and functional testing	2008
WENRA	RL P	Periodic safety review	2008
IAEA	SRS 57	Safe Long Term Operation of Nuclear Power Plants	2008
IAEA	SRS 62	Proactive Management of Ageing for Nuclear Power Plants	2009
IAEA	TECDOC 1147	Management of ageing of I&C equipment inn NPP	2000
IAEA	TECDOC 1361	Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety Primary Piping in PWRs	2003
IAEA	TECDOC 1389	Managing modernization of NPP instrumentation and control systems	2004
IAEA	TECDOC 1402	Management of lifecycle and ageing at NPPs: improved I&C maintenance	2004
IAEA	TECDOC 1556	Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: PWR Pressure Vessels	2007
IAEA	TECDOC 1557	Management of life cycle and ageing at nuclear power plants: Improved I&C maintenance	2007

Germany:

- **Radiation Protection Ordinance:** Requirements for maintenance, inspection and leakage testing of the casing for enclosed radioactive substances whose activity exceeds specified limits (not only BTP)
- **German Reporting Ordinance (AtSMV)**: Requirements for reporting of events
- **KTA-3211.4**: Requirements for recurrent inspections of pressure and activity retaining components of systems outside the primary circuit
- **KTA-1403**: Requirements for ageing management in nuclear power plants

United States:

- The regulations in 10 CFR 50.55a, “Codes and Standards,” require the application of various codes and standards such as the ASME Code.
  - Section III of the Code applies to the design of safety-related pressure boundary components (including buried piping) in nuclear power plants.
  - Section XI of the Code provides requirements for the examination and testing of safety-related buried piping. Among the requirements established by Section XI is a requirement to perform periodic flow tests of safety-related piping, including buried piping. The flow tests ensure piping segments are capable of performing their safety function of delivering fluid in

the appropriate quantity upon demand. In practice plants test some safety-related piping every ninety days.

- 10 CFR 50.55a requires that once leakage through the wall of Class 3 piping is discovered, it must be repaired. However, the regulation permits the licensee to postpone the repairs for up to 24 months, depending on operational circumstances. These requirements apply equally to buried piping and to piping that may be more accessible, such as inside buildings.
- Licensees are required to evaluate the leakage to ensure the piping remains capable of performing its safety function until such time as repairs can be accomplished. These requirements provide flexibility to perform repairs on a schedule that permits adequate planning while still ensuring the piping always remains capable of performing its safety function.

- Licensees are required to maintain radioactive effluents, either from pipe leakage or from normal operations, within NRC regulatory limits and design objectives. The NRC limits for radioactive effluents are contained in 10 CFR 20.1301, "Dose Limits for Individual Members of the Public," and the design objectives are contained in 10 CFR 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents."
- These limits and design objectives are incorporated into the licensing basis for each site (e.g. licensee's technical specifications and Offsite Dose Calculation Manual (ODCM)).
- The effluent concentration limits of 10 CFR 20, Appendix B, Table 2 (10 CFR 20.1302(b)) would be applicable to members of the public. These regulations limit the potential dose to members of the public that could result from an inadvertent release of radioactive material.
- Plants who are applying or will apply for license renewal will be subject to the guidance provided in NUREG 1801 (GALL Report), Revision 2, Aging Management Program (AMP) XI.M41, Buried and Underground Piping and Tanks as amended by NRC Interim Staff Guidance LR-ISG-2015-01.
- These documents describe approaches for inspection and maintenance of buried and underground piping that, if adopted by the applicant, the NRC finds to be acceptable.
- Licensees who have already completed license renewal would adopt these or similar approaches as they update their ageing management programmes in response to operating experience.

9. Please identify any other governing bodies that have regulatory responsibilities associated with BTP systems or leakage in these systems and briefly summarise their roles and responsibilities.

Canada: An Authorised Inspection Agency (AIA, provincial boiler and pressure vessel authority). is an organisation designated by the CNSC as authorised to register designs and procedures, perform inspections, and other functions and activities as defined by the CSA standard N285.0 and its applicable referenced publications (e.g. CSA standard B51, ASME Boiler & Pressure Vessel Code, National Board of Boiler Inspectors). In order for the licensee to fulfil their obligations, they must obtain the services of an AIA to perform activities as defined by standards.

Slovak Republic: The Health and Safety Occupational Office (the state labour inspection office) plays a marginal role in BTP regulation related to the worker safety. The Ministry of the Environment of the Slovak Republic also plays a marginal role in BTP regulation because there is no tritium in BTP.

JRC: N/A

Czech Republic:

- The State Labour Inspection Office – marginal role **-** workers safety
- Ministry of the Environment of the Czech Republic – marginal role – there is no tritium in BP

Switzerland:

- Within the Swiss Association for Technical Inspections the Pressure Vessel Inspectorate (SVTI) is a Technical Support Organisation (TSO) for companies among others dealing with water polluting liquids.
- In connection with this, the Pressure Vessel Inspectorate is responsible for example for the following tasks:
  - Update and maintain information regarding the best available technology for plastic and metal tanks.
  - If tanks are repaired or replaced check the compliance with the technical guidelines.
  - Perform inspections of plastic and metal tanks based on the requirements of the technical guidelines.
  - Perform inspections of custom-built tanks

Netherlands: The licensing of nuclear installations and the definition of the nuclear safety standards to be applied are both the responsibility of the Dutch Ministry of Economic Affairs, Agriculture & Innovation. Depending on the subject (e.g. integrity of the dyke), several public surveillance and inspection organisations also have authority such as Rijkswaterstaat and the Province of Seeland.

Germany:

- **BMU (Ministry of Environment):** Ultimate supervision of German nuclear facilities
- **BfS**: The BfS is working for the safety and protection of people and the environment from damage caused by ionising and non-ionising radiation
- **The Länder-Authorities**: Supervision of German nuclear facilities

United States:

- The U.S. Department of Transportation regulates buried piping and tanks that contain petroleum products or hazardous chemicals. The DOT regulations are comprehensive with respect to design, maintenance, inspection and repair, but they are not applicable within the boundary of a nuclear power facility.
- The US Environmental Protection Agency establishes safe limits for the concentration of tritium in drinking water.
  - These limits have been adopted by the nuclear industry as a measure of merit for the nature of a leak, but are not specifically applicable to nuclear power plants unless a leak were to migrate outside the site boundary into a drinking water source at a concentration that exceeded the limit.

– There has not been an instance where leakage from underground or buried components has created a challenge to the drinking water limits in groundwater used as a drinking water source, although there was an instance where a leak onto the ground from above ground piping (a valve leak) ended up creating contamination in an offsite drinking water supply.

10. If both your organisation and any other governing bodies share regulatory responsibilities, please differentiate the roles and responsibilities among your organisation and the other governing bodies.

Czech Republic: Not applicable

Canada: CNSC role is focused on nuclear safety. Provincial authorities are focused on conventional and worker safety. An AIA is an organisation designated by the CNSC as authorised to register designs and procedures, perform inspections, and other functions and activities as defined by the CSA standard N285.0 and its applicable referenced publications.

Slovak Republic: Not applicable.

Switzerland:

- ENSI is the national regulatory body with responsibility for the nuclear safety and security of Swiss nuclear facilities. ENSI oversees the safety-related SCC's.
- Within the SVTI, the Nuclear Inspectorate is a TSO working on behalf of the ENSI.
- Within the SVTI, the Pressure Vessel Inspectorate is responsible for safety of conventional pressure equipment and systems and tank inspections.

JRC: Not applicable

Netherlands:

- Ministry of Economic Affairs, Agriculture & Innovation: Licensing and regulation
- Human Environment and Transport Inspectorate of the Ministry of Infrastructure and the Environment: Supervision of nuclear facilities based on existing licence(s);
- Rijkswaterstaat (an executive arm of the Dutch Ministry of Infrastructure and the Environment): Dykes in the vicinity of nuclear installations.

Germany:

- The BMUB (Ministry of Environment) is the ultimate nuclear supervisor in Germany in the field of nuclear safety.
- The individual state authorities (ministries) supervise the nuclear installations in the respective federal state.
- GRS as the German TSO supports the BMUB in the field of nuclear safety

United States: As indicated in the previous section, the US NRC does not typically share regulatory responsibility for buried and underground piping with other governing bodies.

***11. Please summarise any research that your organisation (or another government body with responsibilities identified in Question 9 above) is sponsoring related to managing or detecting leakage (or degradation) in BTP*.**

Czech Republic: There is currently no research under way related to this issue. NRI has more than 10 years of expertise on material research and field measurements of the BPT degradation. Several studies of both short and long-term degradation processes in the buried pipeline were made.

Canada: None currently

Slovak Republic: A survey on evaluation of condition of ESW piping has been initiated in 2010. A study on replacement and monitoring of condition (incl. detection of a potential leakage) of buried piping (ESW, SW) has been completed. A technical survey on ESW piping in the concrete block was performed in 2013, and then again in 2015.

Switzerland: No current activities related to managing or detecting degradation in BTP

JRC: None specifically addressing managing & detection of leakage in BTP; only research on corrosion phenomena in primary piping.

Netherlands: Our organisation is not sponsoring research activities related to managing or detecting leakage (or degradation) in BTP.

Germany: GRS on behalf of the BMU has recently evaluated the German operation experience with safety-related service water systems. The evaluation revealed a couple of events on buried pipes without tritium leakage.

United States: The US NRC has sponsored research related to the detection and consequences of degradation of buried and underground piping.

- NUREG/CR-6876, “Risk-Informed Assessment of Degraded Buried Piping Systems in Nuclear Power Plants,” evaluates corrosion damage on buried pipe and concludes that structural integrity can be maintained even with relatively high levels of general wall thinning.
- NUREG/CR-7029, “Lessons Learned in Detecting, Monitoring, Modelling and Remediating Radioactive Ground-Water Contamination,” documents activities used to manage contamination issues through source control, monitoring, modelling, plume and risk management, and communications.

D. Industry responsibilities, plans and initiatives

12. Please summarise any other responsibilities that the nuclear industry in your country has related to ageing management or inspection of BTP that are in addition to their responsibilities to satisfy applicable regulatory and codes/standards requirements. For example, a voluntary industry program may exist to manage degradation in BTP that all the nuclear plants agree to enact.

Czech Republic: There are currently plans to enter BP group of EPRI to establish and follow good practices regarding BPT degradation.

Canada:

- Industry members are participating in the ASME Section XI Task Groups.
- Industry is working on the development of a CSA Standard for periodic inspection of balance-of-plant periodic inspection programmes.

Slovak Republic: Not applicable

Switzerland: There are no additional responsibilities for the nuclear industry.

JRC: Not applicable

Netherlands: According to Dutch and European regulations, the operator of KCB is obliged to implement and to run a system to continuously improve their BTP management.

- Within the recently started 3rd PSR of the Borssele power plant, the operator will evaluate the state of the art concerning ageing management and in service-inspection. Furthermore, the licensee will generically address leakage from BTP.
- The operator has also been asked by KFD to evaluate the existing program for soil sampling and determine if improvements are needed.

Germany: GRS knows of no current industry commitments.

United States:

- The US industry communicated its plan to address buried piping integrity in its November 2009 letter "Industry Initiative on Buried Piping Integrity" (NRC Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML093350034 and ML093350035).
  - The scope of this first underground piping initiative only addressed piping that is directly buried in soil.
  - However, because operating experience which revealed that leakage of tritiated water from underground piping in vaults or chases (but not in contact with soil) could also lead to groundwater contamination, the industry expanded the scope of its first initiative to include underground piping not in direct contact with the soil and selected underground tanks.
- September 2010 letter "Industry Initiative on Underground Piping and Tanks Integrity" describes its revised commitments.
  - This second initiative contains all of the requirements and objectives from the first initiative but adds underground piping and tanks that are outside of a building and below the surface of the ground (whether or not they are in direct contact with the soil) if they are safety-related or contain licensed material or are known to be contaminated with licensed material.
  - Also, an owner's piping located outside the owner controlled area is considered to be within the scope of the underground piping and tanks integrity initiative if it is safety-related or contains licensed material.
- In February, 2013, the industry issued revisions to these initiatives to align their scopes and to revise some milestone due dates.

- The industry issued a guidance document, Nuclear Energy Institute (NEI) 09-14, "Guideline for the Management of Buried Piping Integrity" (NRC ADAMS Accession No. ML1030901420) to describe a licensee's goals and required actions (commitments made by the licensee) resulting from this underground piping and tank initiative. NEI later issued NEI 09-14, Revision 1, "Guidance for the Management of Underground Piping and Tank Integrity," on December 31, 2010 (NRC ADAMS Accession No. ML110700122), Revision 2 in November, 2012 (NRC ADAMS Accession Nos.ML13086A086 and ML13086A089), and Revision 3 in April 2013 (NRC ADAMS Accession No. ML13130A322).
- An Electric Power Research Institute (EPRI) document "Recommendations for an Effective Program to Control the Degradation of Buried and Underground Piping and Tanks" is a guidance document that provides additional details on the buried pipe and tank initiative elements and attributes to incorporate into a licensee's buried pipes and tanks program.
- Alternative documents such as those produced by NACE International also provide acceptable guidance.
- Under the Underground Piping and Tanks Integrity Initiative, each site is to develop and implement either a site-specific or company program for buried piping and underground piping and tanks.
  - Both initiatives have five elements: procedures and oversight, risk ranking, inspection planning, inspection implementation and asset management.
  - The overall objective of the initiatives is to ensure structural and leak tight integrity of important underground and buried piping and tanks.
  - Every utility has expressed its intent to comply with the initiatives.
  - Implementation of the initiatives is validated by periodic inspections by the Institute for Nuclear Power Operations. Additionally, the NRC is inspecting the implementation of the initiatives via a temporary inspection, TI-182.
- The industry also established a Groundwater Protection Initiative which establishes expectations with respect to discovery and reporting of groundwater contamination, including groundwater contamination that originates from leaks in buried or underground piping and tanks.
  - All utilities have committed to follow this initiative.
  - Implementation is verified by inspections by INPO and initially by an NRC temporary instruction. The NRC temporary instruction has been completed. Aspects of the TI have been incorporated into the base inspection program to ensure that all licensees implement the Groundwater Initiative in a committed and enduring fashion.
- Relevant references for the initiatives and other industry guidance of complying with the initiatives include:
  - NEI 09-14, Rev 3, "GUIDELINE FOR THE MANAGEMENT OF UNDERGROUND PIPING AND TANK INTEGRITY" (NRC ADAMS ML13130A322)
  - NEI Revision to the Industry Initiative on Underground Piping and Tanks Integrity, February 8, 2013
  - Underground Piping and Tanks Integrity Initiative, September 27, 2010
  - Industry Initiative on Groundwater Protection, July 31, 2006 (NRC ADAMS ML062260198)

– Industry Initiative on Buried Piping Integrity, November 20, 2009 (NRC ADAMS ML093350032)

13. Please describe any plans or initiatives that your nuclear industry has enacted related either to ageing management or inspection of BTP. As part of this description, please include any research that is being conducted related to managing or detecting leakage (or degradation) in BTP.

Czech Republic: There is an ongoing project on BP, which summarises available codes and standards including US ones, to create a proposal for a BP program for Czech NPPs. This activity is operator driven and is not requested by authorities.

Canada:

- CNSC oversees the implementation of periodic inspection programmes for nuclear safety-related pressure-boundary components. CNSC monitors S-99 reports on degradation of pressure boundaries. An operating licence condition has been added requiring licensees to implement regulated inspection programmes for balance-of-plant pressure-boundary components. CSA Standard under development for inspection of balance-of-plant pressure boundary components. Regulatory Document RD-334 has been issued to address Ageing Management of NPPs.
- CANDU Owners Group (COG) issued a R&D report: COG-09-4055 "NDE Methods for Buried Pipe: Review and Best-Practice Recommendations". The report concluded that the methods reviewed by the Electric Power Research Institute (EPRI) are largely applicable to CANDU buried pipe, since the materials and pipe sizes involved are common in both CANDU and non-CANDU plants. The completeness of the presently available methods for application to a CANDU buried pipe assessment program is considered and discussed, and recommendations for avenues of R&D necessary to support a CANDU program are given by the report.

Slovak Republic: An initiative on evaluation of condition of all the relevant piping was started in 2011. As part of this initiative the list of the relevant piping was completed which focused on summarising operational events, failures, repair and replacement, and evaluation of the condition of piping and components with the determination of their reliability. After this evaluation, the prioritised piping systems to be inspected first were then identified in order to assess the actual piping conditions. The systems were prioritised following their safety significance for those piping systems that are related to the safe and reliable operation of the plant. Using this process, the ESW system was inspected first after excavation of selected locations.

Switzerland: No specific initiatives related to AMP or inspection of BTP.

JRC: Not applicable

Netherlands:

- The licence holder of the Borssele NPP has an existing program for ageing management and inspection. This program will be reviewed within the recently started 3rd PSR. Furthermore, KCB is member of the VGB and has access to VGB-initiatives related to BTP.
- KCB intends to apply for long-term operation (LTO-project) from 40 to 60 years. Ageing management of BTP is addressed as part of that project as well.

Germany:

- GRS knows of no specific initiatives related to ageing management or inspection of BTP that have been enacted by the German nuclear industry.
- Background: LTO is not intended in Germany

United States: The industry has established a Buried Piping Integrity Group under the auspices of the Electric Power Research Institute to provide high-level oversight of the initiatives. Additionally, this group sponsors research through EPRI.

- Ongoing programmes include development of risk ranking software; development and evaluation of remote inspection technology and delivery tools; design, maintenance, and evaluation of cathodic protection; and development and validation of non-destructive examination techniques for buried and underground piping.
- http://pbadupws.nrc.gov/docs/ML1129/ML11297A002.pdf provides a research overview.

E. Technical and regulatory concerns

14. ***Please summarise any technical issues and concerns that your organisation and country have related to ageing management, leakage, and inspection of BTP.***

Canada: Require a more structured monitoring and oversight process.

Slovak Republic: Excavation of selected locations of ESW piping were carried out after leakages were found in these systems. Visual and ultrasonic inspection were performed as well. Both replacement and repair of sections of ESW intake piping are currently under way. The repair is being performed by recoating the piping from the outer diameter.

Switzerland: We are aware of some MIC and pitting issues of buried auxiliary cooling water systems. Additionally the inner coating of some pipes is degraded. Maintenance work is ongoing, e.g. replacement of pipes and recoating of existing pipes.

JRC:

- BTP of NPPs around the world that showed leakages were never designed to be inspected, because the original design life of these reactors was mostly 30 years. With LTO of NPPs inspection of BTP becomes an issue.
- In conjunction with LTO, possible mitigation & repair strategies for BTP
- Is BTP prone to specific types of corrosion?

Czech Republic: A leakage of BP is not a problem and is limited to some systems only. Most BPs in the plants are encased in concrete and are equipped by manholes. Some corrosion was observed on raw water piping at Temelin plant and tap water piping at Dukovany. The second one will be probably repaired by inner lining next year or in 2013.

Netherlands:

- In 2009, degradation and settling of buried cooling water lines (steel pipelines with inner and outer concrete liner, diameter 2.5 – 3 m) was detected at the Borssele NPP which could potentially affect the availability of the service water lines/ultimate heat sink in case of failure.
  - The cooling water intake building and the cooling water outlet building are concrete structures that supply and discharge KCB cooling water. Both are mat foundations with projecting members and embedded parts allowing further pipe connections.
  - The cooling water piping for the main cooling water system (VC) and auxiliary and emergency cooling water system (VF) are composed of composite concrete/steel piping and connect the sea site structures of intake and outlet buildings with plant cooling water processing facilities. These systems are only accessible from the inside.
- The operator of KCB partly applies "corrective maintenance" for some SCCs in place of predictive maintenance. Discussions with the operator have been initiated about this topic.

Germany:

- Usually leakage events of aboveground pipes/vessels are detected during regular plant inspection,
- However, as operating experience has shown, in some cases smaller leakage of buried pipes has remained undetected.
  - The root cause of these events was usually corrosion (MIC, pitting corrosion, shallow pit corrosion) mostly as a consequence of degradation of the inner coating and to a lesser extent of the outer coating.
  - Another potential failure mechanism observed in this context is erosion.
  - Undetected leakage due to corrosion/erosion can cause erosion of soil under the affected pipe and also of neighbouring pipes so that they are no longer supported. In a worst case scenario this can lead to a sudden pipe rupture.

United States:

- There are no current technical issues with respect to safe operation of nuclear power plants that result from degradation of buried or underground piping and tanks issues.
- The NRC performed a review of the issues associated with degradation of buried and underground piping in SECY 09-0174 (http://pbadupws.nrc.gov/docs/ML0931/ML093160004.pdf).
  - Stated simply, degradation of buried piping can be managed by inspection followed by repair and replacement if necessary.
  - Inspection can be accomplished by excavation and visual and qualified non-destructive examination.
  - Repairs and replacements can be accomplished during an excavation.
- Current technical issues associated with buried and underground piping and tanks are directed toward reducing the cost and improving the reliability of inspection and repair activities. These types of technical issues are typically addressed by industry.

15. ***Please summarise the plans and/or activities that are being conducted to address the technical issues and concerns identified in Question 14. As part of this summary, please identify, for each activity, if they are being sponsored and conducted by a government body or by the commercial nuclear industry.***

Canada: CSA Standard under development for inspection of balance-of-plant pressure boundary components – industry and government participation.

Slovak Republic:

- An initiative on evaluation of condition of all the relevant piping
- Participation on workshops on the relevant topic
- Preparation of testing of new methods of BTP condition monitoring

Switzerland: Utilities affected by degraded BTP have lunched special maintenance measures in order to ensure integrity of non-safety relevant BTP.

JRC: None specifically at JRC-IET

Czech Republic: Solving leakage issues in the raw water piping at the Temelin plant and the tap water piping at the Dukovany plant is being sponsored by plant owner

Netherlands:

- A safety analysis and action plan was developed by the operator in 2009 together with an increased monitoring and inspection (inline) regime required a hardware modification.
- The harsh sea environment of the cooling water intake and outlet buildings site promotes the effect of ageing and the related mechanisms.
- Concrete spalling and exposed grain, primary at most exposed edges as well as steel coating require repair.
- Those essential repair activities are planned for 2011 - 2012.
- The hardware modification consists of the partial renewal of the piping in connection with a new routing of the service water piping.

Germany:

- To address the issues identified in Question 14, the corresponding KTA standard (KTA-3211.4) has recently been updated.
- The new release of KTA 3211.4 basically includes more in-service-testing requirements for the in-scope systems structures and components.

United States: EPRI has produced the following products related to buried and underground piping and tanks:

- Buried Pipe

- Computer Based Training (CBT) Buried Pipe Condition Assessment and Repair, Version 1.0, December 2011, EPRI Report 1023249
- Evaluation of Indirect Assessment Techniques for Coating Flaw Detection, December 2011, EPRI Report 1022962
- Slow Crack Growth Testing of High-Density Polyethylene Pipe: 2011 Update, December 2011, EPRI Report 1022565
- Early Detection of Leaks in Buried Piping, December 2011, EPRI Report 1022963
- Balance-of-Plant Corrosion – The Buried Pipe Reference Guide, December 2010, EPRI Report 1021470
- Recommendations for an Effective Program to Control Degradation of Buried and Underground Piping and Tanks (1016456, Revision 1), December 2010, EPRI Report 1021175
- BPWorks Version 2.0, November 2010, EPRI Report 1020383
- Capacity Testing of Cured-in-Place Pipe, December 2009, EPRI Report 1019179
- Buried Pipe End-of-Expected-Life Considerations and the Need for Planning, December 2008, EPRI Report 1016687
- Catawba Field Trial of EPRI's Large Diameter Buried Pipe-line Instrumented Vehicle, December 2008, EPRI Report 1016676
- Nondestructive Evaluation: Further Developments of Guided Wave Examination Application, December 2008, EPRI Report 1016675
- Recommendations for an Effective Program to Control the Degradation of Buried Pipe, December 2008, EPRI Report 1016456
- An Assessment of Industry Needs for Control of Degradation in Buried Pipe, March 2008, EPRI Report 1016276
- Examination of Large Diameter Buried Piping for Small Pit Detection and Preferential Weld Corrosion Attack, December 2007, EPRI Report 1015056
- Condition Assessment of Large Diameter Buried Piping, Phase 3 – Field Trial, December 2006, EPRI Report 1013468
- Condition Assessment of Large Diameter Buried Piping, Phase 2 – Vehicle Design and Construction, December 2005, EPRI Report 1011829
- Condition Assessment of Large Diameter Buried Piping, Phase 1 – Feasibility, November 2004, EPRI Report 1008186
- Evaluation of Torsional Guided Waves for Inspection of Service Water Piping, December 2000, EPRI Report 1000115

• Buried Pipe NDE

- Nondestructive Evaluation: Remote Field Technology Assessment for Piping Inspection Including Buried and Limited Access Components, November 2010, EPRI Report 1021153
- Buried Pipe Guided Wave Examination Reference Document, October 2009, EPRI Report 1019115

  - Cathodic Protection System Application and Maintenance Guide, December 2005, EPRI Report 1011905
  - Buried Pipe Condition Assessment with Instrumented Vehicles, November 2003, EPRI Report 1007947

- Additional information about ongoing industry research and development programmes can be found here: http://pbadupws.nrc.gov/docs/ML1234/ML12345A254.pdf and here: http://pbadupws.nrc.gov/docs/ML1129/ML11297A002.pdf . The latter document contains a roadmap of ongoing EPRI activities.

16. Are there safety-related buried or underground piping whose condition can only be assessed by excavation (safety-related pipes that do not contain tritium, such that degradation or leakage cannot be detected by groundwater monitoring)?

Canada: Yes. There is some buried emergency core cooling piping. There may be other systems. However, based upon our experience, this has not been a significant issue for CANDU plants to date.

Slovak Republic: Yes

Switzerland: Yes, there are a very limited number of buried safety-related pipes. These pipes do not contain tritium.

JRC: Not applicable

Czech Republic: Yes

Netherlands: Yes, fire hydrants and related piping.

Germany: Yes, there is a limited number of buried safety-related pipes, e.g. safety-related service water systems. However these pipes do not contain H-3.

United States: There are examples of safety related, ASME code class 3 buried and underground piping that do not carry tritiated water.

- For these systems, groundwater monitoring for tritium contamination would not be a useful method for detecting leakage.
- One method of evaluating the condition of this type of piping would be direct inspection after excavation.
- There are a variety of direct and indirect inspection techniques, however, that may be useful and that do not require excavation.
  - For piping that has sufficient access and less tortuous routing, pigs, crawlers and other internally delivered NDE platforms can provide direct inspection, both visual and ultrasonic or electromagnetic, that enable the owner to appropriately diagnose the piping condition on both the ID and OD of the pipe.
  - Indirect inspection techniques such as guided wave UT, or electrochemical techniques such as potential surveys, voltage gradient surveys, or other techniques offer the ability to monitor underground piping for degradation without excavation. The indirect techniques must be validated by some amount of direct inspection.

17. ***What types of indirect assessment techniques are required to be used in your country and how are the techniques credited (for example, guided wave, potential surveys, etc.)?***

Canada: None currently required by regulation.

Slovak Republic: Guided wave inspection is not used because pipe insulation is made from bitumen which causes large signal attenuation. Buried piping placed in concrete is regularly monitored by the georadar method.

Switzerland: There are no specific requirements regarding indirect assessment techniques. All inspection methods for safety-related SCC have to be qualified according to ENSI-B07.

JRC: Not applicable

Czech Republic: Guided wave inspection is not used because most of the BP is in concrete. The resistivity between soil and piping is measured on some systems (e.g. the raw water piping in the Dukovany plant).

Netherlands: Leakage detection (e.g. in water intake building), deformation measurements of piping, salinometer survey in the soil of the dyke between the Borssele NPP and the North Sea, non-destructive testing methods, robot-inspections, walkthrough (service water lines).

Germany:

- According to KTA 3211.4, recurrent visual inspections (integral, selective) have to be performed on the inner and outer surface of vessels.
- For buried vessels, this is only possible from the inside surface.
- In addition, selective visual inspections are to be performed on the outside surface of ferritic and austenitic pipes > DN 50, wherein the extent of testing shall be specified on a plant specific basis.
- In some cases, inspections are performed by measuring the resistivity between the soil and piping.
- The application of guided wave ultrasound techniques is not known to GRS.

United States:

- The only indirect inspection requirement for nuclear power plants in the United States is a system pressure or flow test as described in American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Article IWA-5244 and incorporated by reference into Federal regulation in 10 Code of Federal Regulations (CFR) 50.55a(b).
- Information regarding the use of indirect inspections is also contained in the NUREG 1801 (GALL Report), Revision 2, Aging Management Program (AMP) XI.M41, Buried and Underground Piping and Tanks as amended by NRC Interim Staff Guidance -ISG-2015-01 and the nuclear power industry’s Underground Piping and Tanks Integrity Initiative.
  - Information contained in the GALL report is applicable only to plants that are applying or will apply for renewed licences. This information constitutes one approach, which is acceptable to the NRC, by which licensees may manage the ageing of buried piping and tanks.

- Information contained in the industry Underground Piping and Tanks Integrity Initiative is considered to be mandatory within the industry but voluntary with respect to the NRC as this information has not been incorporated into Federal regulation.
- Both documents recommend the use of any available indirect inspection techniques to establish the most critical locations in which to perform direct examinations.

18. Please indicate any applications or uses, if any, which require cathodic protection. If cathodic protection is used, please identify any requirements for surveying cathodic protection systems.

Canada: CSA standard B51 refers to CSA Z662 for the requirement of buried piping catholically protecting, and monitoring. But we currently do not have collected data through from licensees.

Slovak Republic: Cathodic protection is used to protect the raw water inlet piping to the plant (Mochovce) from the river. This protection is currently under reconstruction, which means that the new requirements will be established afterwards. In accordance with the design this is the only piping protected by such measures. An ESW reconstruction project that includes the installation of cathodic protection is currently ongoing in Bohunice NPP

Switzerland: No cathodic protection for BTP systems.

JRC: Not applicable

Czech Republic: We do not know definitively if cathodic protection (CP) is used, but if it is, it is very limited. Most of the BP has no CP. I have no information on CP and requirements.

Netherlands: In case of the buried cooling water lines (see answer to questions 14 and 15) cathodic protection is not applied because of the inner and outer concrete liner of pipes which are meant to protect the inner steel pipes.

Germany: GRS is only aware that cathodic protection is used in German NPPs for the buried parts of service water systems, but there are no corresponding requirements in the KTA standards.

United States:

- There are no requirements for the use of cathodic protection at nuclear power plants in the United States.
- Notwithstanding this lack of requirements for the use of cathodic protection to protect buried piping and tanks at US nuclear power plants, information on this subject is contained in the NUREG 1801 (GALL Report), Revision 2, Aging Management Program (AMP) XI.M41, Buried and Underground Piping and Tanks as amended by NRC Interim Staff Guidance -ISG-2015-01 and the nuclear power industry's Underground Piping and Tanks Integrity Initiative.
  - Information contained in the GALL report is applicable only to plants that are applying or will apply for renewed licences. This information constitutes one approach, which is acceptable to the NRC, by which licensees may manage the ageing of buried piping and tanks.
  - Information contained in the industry Underground Piping and Tanks Integrity Initiative is considered to be mandatory within the industry but voluntary with respect to the NRC as this information has not been incorporated into Federal regulation.

- Information in these documents concerning the use of cathodic protection references NACE Standard SP0169, "Control of External Corrosion on Underground or Submerged Metallic Piping Systems." This standard addresses maintenance and survey requirements. The GALL report places conditions on the use of SP0169 relative to demonstration of when cathodic protection is not required and the pipe to soil potentials which are used to demonstrate the adequacy of cathodic protection.

19. *Please describe any potential gaps in your country's current regulations (or regulatory framework) that may need to be addressed to provide reasonable assurance that leakage from BTP will not pose a significant public health and safety concern.*

Canada: Limited oversight of inspection programmes for balance-of-plant pressure boundary components.

Slovak Republic: Not aware of any gaps

Switzerland: After final water treatment is passed, plant is allowed to discharge very light contaminated water within the strict regulatory limits into rivers. A potential leakage in a discharge pipe could lead to an unexpected enrichment of contamination close to the discharge pipe (due to the missing dilution). This issue is under discussion within the regulatory body.

JRC: Not applicable

Czech Republic: Not aware of any gaps.

Netherlands: No gaps have been identified

Germany: GRS is not aware of any gaps that need to be addressed

United States:

- The NRC recognises that degradation of buried and underground piping and tanks could, in the long term, if left undiagnosed and uncorrected, lead to challenges to the leak tightness of systems containing licensed or environmentally hazardous materials, or could challenge piping system structural integrity.
- At this point in time, the industry has developed initiatives to address design, maintenance, monitoring, inspection, repair and asset management of buried and underground piping and tanks and an initiative to address groundwater protection to address discovery, reporting and remediation of events where radioactive material is inadvertently released into a pathway that could affect groundwater.
- In SECY 11-0019 and SECY 11-0076 the staff recommended following the industry activities to determine whether, among other things, the initiatives accomplished the objectives of ensuring leak tightness and structural integrity of relevant buried and underground piping and tanks. The Commission directed the staff to monitor the implementation of the industry initiatives rather than embarking on a path to incorporate the initiative requirements into the regulatory framework.
- Therefore, there are currently no gaps in the regulatory framework.

20. Please summarise your country's plans to address any regulatory gaps that may currently exist.

Canada: New CSA Standard governing inspection requirements for balance-of-plant pressure boundary components being developed will be incorporated into operating licences.

Slovak Republic: Not aware of any gaps

Switzerland: No actions planned at this time.

JRC: N/A

Czech Republic: Not aware of any gaps.

Netherlands: Not applicable

Germany: Not applicable

United States:

- The NRC, through temporary inspection instructions and baseline inspections of licensee implementation of the industry initiatives, is evaluating whether the initiatives are being implemented in a committed and enduring fashion.
- If at some point in time the staff determines that any of the initiatives are not being implemented in a committed and enduring fashion, then a potential regulatory gap would exist.
- At that point the staff would inform the Commission of the potential need for a regulatory response.