Nuclear Safety
NEA/CSNI/R(2015)17
October 2015
www.oecd-nea.org

Workshop on Collection and Analysis of Common-Cause Failures due to External Factors

International Common-Cause Failure Data Exchange (ICDE) Project Report

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Unclassified **NEA/CSNI/R(2015)17**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development **20-Oct-2015**

English text only

NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

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JT03384463

Complete document available on OLIS in its original format

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 34 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, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Republic of Korea, 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, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, the Republic of Korea, the Russian Federation, 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.

THE 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 committee 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's Committee on Nuclear Regulatory Activities (CNRA), which is responsible for the Agency's programme concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also co-operates with the 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.

PREFACE

Common-cause failure (CCF) events can significantly impact the availability of safety systems of nuclear power plants. For this reason, the International Common-Cause Failure Data Exchange (ICDE) Project was initiated by several countries in 1994. In 1997, CSNI formally approved the carrying out of this project within the OECD NEA framework; since then the project has successfully operated over five consecutive terms (the current term being 2011-2014).

The purpose of the ICDE Project is to allow multiple countries to collaborate and exchange common-cause failure (CCF) data to enhance the quality of risk analyses that include CCF modelling. Because CCF events are typically rare events, most countries do not experience enough CCF events to perform meaningful analyses. Data combined from several countries, however, yields sufficient data for more rigorous analyses.

The objectives of the ICDE Project are to:

1. Collect and analyse Common-Cause Failure (CCF) events over the long term so as to better understand such events, their causes and their prevention;

2. Generate qualitative insights into the root causes of CCF events which can then be used to derive approaches or mechanisms for their prevention or for mitigating their consequences;

3. Establish a mechanism for the efficient feedback of experience gained in connection with CCF phenomena, including the development of defences against their occurrence, such as indicators for risk based inspections;

4. Generate quantitative insights and record event attributes to facilitate quantification of CCF frequencies in member countries;

5. Use the ICDE data to estimate CCF parameters.

The qualitative insights gained from the analysis of CCF events are made available by reports that are distributed without restrictions. It is not the aim of those reports to provide direct access to the CCF raw data recorded in the ICDE database. The confidentiality of the data is a prerequisite of operating the project. The ICDE database is accessible only to those members of the ICDE Project Working Group who have actually contributed data to the databank.

Database requirements are specified by the members of the ICDE Project working group and are fixed in guidelines. Each member with access to the ICDE database is free to use the collected data. It is assumed that the data will be used by the members in the context of PSA/PRA reviews and application.

The ICDE project has produced the following reports, which can be accessed through the NEA web site:

- Collection and analysis of common-cause failure of centrifugal pumps [NEA/CSNI/R(99)2], September 1999.

- Collection and analysis of common-cause failure of emergency diesel generators [NEA/CSNI/R(2000)20], May 2000.

- Collection and analysis of common-cause failure of motor-operated valves [NEA/CSNI/R(2001)10], February 2001.
- Collection and analysis of common-cause failure of safety valves and relief valves [NEA/CSNI/R(2002)19]. Published October 2002.
- Collection and analysis of common-cause failure of check valves [NEA/CSNI/R(2003)15], February 2003.
- Collection and analysis of common-cause failure of batteries [NEA/CSNI/R(2003)19], September 2003.
- ICDE General Coding Guidelines [NEA/CSNI/R(2004)4], January 2004.
- Proceedings of ICDE Workshop on the qualitative and quantitative use of ICDE Data [NEA/CSNI/R(2001)8, November 2002.
- Collection and analysis of common-cause failure of switching devices and circuit breakers [NEA/CSNI/R(2008)01], October 2007.
- Collection and analysis of common-cause failure of level measurement components [NEA/CSNI/R(2008)8, July 2008.
- Collection and analysis of common-cause failure of centrifugal pumps [NEA/CSNI/R(2013)2], June 2013.
- Collection and analysis of common-cause failure of control rod drive assemblies [NEA/CSNI/R(2013)4], June 2013.

ACKNOWLEDGEMENTS

The following people have significantly contributed to the preparation of this report by their personal effort: Albert Kreuser (GRS), Anna Georgiadis (ES-konsult), Gunnar Johanson (ES-konsult), Jan Stiller (GRS), Mattias Håkansson (ES-konsult), Roland Beutler (ENSI) and Wolfgang Werner (SAC).

In addition, the ICDE Working Group and the people with whom they liaise in all participating countries are recognised as important contributors to the success of this study. Axel Breest has been the responsible NEA official and contributed to finalising the report.

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EXECUTIVE SUMMARY

In the light of the TEPCO Fukushima accident, this report documents a study performed on a set of common-cause failure (CCF) events due to external factors, meaning that not only storms and hurricanes are included but also high outdoor temperatures and excessive algae growth. The events were derived from the International CCF Data Exchange (ICDE) database, where a brainstorming exercise performed by the OA (Operating Agent) on how to identify interesting events resulted in finding 52 events related to the topic out of 1 600 ICDE events in total. The study is based on a workshop performed during an ICDE Steering Group meeting in April 2012, where the scope of events due to external factors was analysed in work groups. During the workshop 9 events were identified to not have resulted from external factors and therefore outside the workshop scope, i.e. this report includes the assessment of 43 ICDE events.

This report begins with an overview of the entire data set (Section 3). Charts and tables are provided exhibiting the event count for each of event parameters such as component type, failure mode, root cause, coupling factor, detection method and corrective action. Moreover, additional insights from the data are also presented in terms of cross tabulations of some of the event parameters. Here it could be seen that the majority of the events include centrifugal pumps (40%), followed by diesels (30%). The most common failure mode for pumps respectively diesels is failure to run (FR) and demand was the main way of detecting external problems (37%).The high number of demand events suggests that these type of "external failures" may be difficult to detect in periodic tests.

Engineering insights about the collected events are presented (Section 4). The report includes several suggested improvements, lessons learnt and other interesting insights. For context purposes, examples of typical events involving mentioned improvements are presented.

The identified areas of improvements and lessons learnt can be divided into two subcategories – human/operational and hardware related improvements. Both "increased monitoring" and "improved cleaning of strainers" was concluded as important improvements for events involving pumps, diesels and heat exchangers. In addition, there were three events where the surveillance procedure was identified as a successful defence. All three events involve slow processes where excessive sand or shellfish in the sea water causing wear of the pump´s impeller or clogging in the heat exchanger. Due to the slowly developing failure, it was possible to detect the event with differential pressure monitoring before degradation of the pump or heat exchanger.

Three diesel events within three years at the same site experiencing the same failure mechanism are proof that back fitting of operational experience takes a long time. These events involved sludge in the sea water leading to reduced cooling capacity and therefore too high temperatures of the diesel´s cooling water. Here it could be concluded that thorough root cause identification is crucial before continuation of operation to prevent repetition of the failure.

Since many of the events due to external factors involve sea water problems, important hardware improvements involve design changes of the water intake. One diesel event, where sludge in the sea water led to reduced cooling capacity and therefore too high temperatures of the diesel´s cooling water, could have been prevented if the water intake had been diversified. An example of a diversified water intake could be one surface intake and one deep water intake.

Another interesting event was a pump event where both emergency feed water pumps run by diesel engines where degraded due to algae growth in the shared diesel fuel tank. The shared fuel tank is an example of not fully implemented separation of redundant pumps.

Two other interesting aspects were found. The first involves correlated hazards, which should be taken into account for better defence. There is one heat exchanger event where very high water level in combination with high amount of pollution in water such as foliage and grass led to clogging of the tubes in the heat exchangers. The second interesting aspect is related to a service water pump event where it was concluded that there had been "slight impairment by chance" because the detection of low backup seal water supply due to clogging (by sand and corrosion products) was not via monitoring of the flow but by testing of the seal water regulator of pumps with isolated main seal water supply after outage. If the failure progression had been faster, a more severe failure could have occurred before the outage in case of unavailable main seal water supply. Additionally, this event also emphasises the above mentioned observation that back fitting of operational experience takes a long time as four weeks after the first findings, one additional service water pump had been declared out of service when seal water supply was below the required minimum flow rate due to clogging by sand and corrosion products.

As summary and conclusion it is stated that the results of this analysis may serve as input for an in depth review of the methods and assumptions used in external hazards PSA and to support the identification of possible external factors which may have low frequencies but large consequences (section 5).

ACRONYMS

BWR	Boiling Water Reactor
CCF	Common Cause Failure
FO	Failure to open
FR	Failure to run
FS	Failure to start
HT-General	Failure of heat transfer
ICDE	International Common Cause Failure Data Exchange
IRS	Incident Reporting System
LOCA	Loss-of-Coolant Accident
LOOP	Loss of Offsite Power
NPP	Nuclear Power Plant
OA	Operating Agent
OP	Observed Population
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Assessment
PWR	Pressurised Water Reactor
RPS	Reactor Protection System

ORGANISATIONS

AECB	Atomic Energy Control Board (Canada)
CNSC	Canadian Nuclear Safety Commission (Canada)
CSN	Consejo de Seguridad Nuclear (Spain)
CSNI	Committee on the Safety of Nuclear Installations
ENSI	Eidgenössisches Nuklearsicherheitsinspektorat / Swiss Federal Nuclear Safety Inspectorate (Switzerland)
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit (Germany)
IRSN	Institut de Radioprotection et de Sûreté Nucléaire (France)
JNES	Japan Nuclear Energy Safety Organisation (Japan)
KAERI	Korea Atomic Energy Research Institute (Republic of Korea)
NEA	Nuclear Energy Agency
NRC	Nuclear Regulatory Commission (USA)
NRI	Nuclear Research Institute Rez plc (Czech Republic)
OECD	Organisation for Economic Co-operation and Development
ONR	Office for Nuclear Regulation (UK)
SSM	Swedish Radiation Safety Authority (Sweden)
STUK	Finnish Centre for Radiation and Nuclear Safety (Finland)

GLOSSARY

- **Common-Cause Failure Event**: A dependent failure in which two or more component fault states exist simultaneously, or within a short time interval, and are a direct result of a shared cause.

- **Complete Common-Cause Failure:** A common-cause failure in which all redundant components are failed simultaneously as a direct result of a shared cause (i.e., the component impairment is 'Complete failure' for all components and both the time factor and the shared cause factor are 'High').

- **Component:** An element of plant hardware designed to provide a particular function.

- **Component Boundary:** The component boundary encompasses the set of piece parts that are considered to form the component.

- **Coupling Factor/Mechanism:** The coupling factor field describes the mechanism that ties multiple impairments together and identifies the influences that created the conditions for multiple components to be affected.

- **Defence:** Any operational, maintenance, and design measures taken to diminish the probability and/or consequences of common-cause failures.

- **Exposed Population (EP):** A set of similar or identical components actually having been exposed to the specific common causal mechanism in an actually observed CCF event.

- **Failure:** The component is not capable of performing its specified operation according to a success criterion.

- **Failure Cause:** The most readily identifiable reason for the component failure. The failure cause category is specified as part of the failure analysis coding, which provides additional insights related to the failure event.

- **Failure Cause Categories:** A high level and generalised list of deficiencies in operation and in design, construction and manufacturing which caused an ICDE event to occur.

- **Failure Mechanism:** The history describing the observed events and influences leading to a given failure. Elements of the failure mechanism could be a deviation or degradation or a chain of consequences. It is derived from the event description.

- **Failure Mechanism Categories:** Are component-type-specific groups of similar Failure mechanism sub-Categories.

- **Failure Mechanism Sub-Categories:** Are coded component-type-specific observed faults or non-conformities which have led to the ICDE event.

- **Failure Mode:** The failure mode describes the function the components failed to perform.

- **Degraded Failure:** The component is capable of performing the major portion of the safety function, but parts of it are degraded. For example, high bearing temperatures on a pump will not completely disable a pump, but it increases the potential for failing within the duration of its mission.

- **ICDE Event:** Impairment 1) of two or more components (with respect to performing a specific function) that exists over a relevant time interval 2) and is the direct result of a shared cause.

- **Incipient Failure:** The component is capable of performing the safety function, but parts of it are in a state that – if not corrected – would lead to a degraded state. For example, a pump-packing leak, that does not prevent the pump from performing its function, but could develop to a significant leak.

- **Observed Population (OP):** A set of similar or identical components that are considered to have a potential for failure due to a common-cause. A specific OP contains a fixed number of components. Sets of similar OPs form the statistical basis for calculating common-cause failure rates or probabilities.

- **Root Cause:** The most basic reason for a component failure, which, if corrected, could prevent recurrence. The identified root cause may vary depending on the particular defensive strategy adopted against the failure mechanism.

- **Shared-Cause Factor:** The shared cause factor allows the analyst to express his degree of confidence about the multiple impairments resulting from the same cause.

- **Time Factor:** This is a measure of the 'simultaneity' of multiple impairments. This can be viewed as an indication of the strength-of-coupling in synchronising failure times.

1. INTRODUCTION

In the light of the TEPCO Fukushima accident, a workshop on CCF events due to external factors was performed during the ICDE Steering Group meeting in April 2012. The results of the workshop may serve as input for an in depth review of the methods and assumptions used in external hazards PSA. This report summarises the workshop results and presents an overview of the exchange among several countries of CCF data of failures due to external factors. The objectives of this report are:

- To describe the data profile of the ICDE events due to external factors;
- To develop qualitative insights in the nature of the reported events, expressed by root causes, coupling factors, and corrective actions; and
- To develop the failure mechanisms and phenomena involved in the events, their relationship to the root causes, and possibilities for improvement.

Section 2 presents a description of the event data "external factors". An overview of the contents of the external factors database and summary statistics are presented in Section 3. Section 4 contains some high level engineering insights about the CCF events due to external factors. These insights are based on failure mechanisms and failure causes. Section 5 provides a summary and conclusions. References are found in Section 6.

The ICDE Project was organised to exchange CCF data among countries. A brief description of the project, its objectives, and the participating countries, is given in Appendix A. Appendix B presents the definition of common-cause failures and the ICDE event definitions.

Other international activities related to the TEPCO Fukushima accident are summarised by STG-FUKU (NEA Senior-level Task Group on the Impacts of the Fukushima Daiichi NPP Accident) in [1]. The report outlines the actions taken by NEA and its member countries. Also key messages and their implications for ensuring high levels of nuclear safety are summarised.

2. EVENT DATA DESCRIPTION

2.1 Preparation of event data "external factors"

The preparation started with a brainstorming exercise performed by the OA (Operating Agent), where the method on how to identify interesting events to the workshop was discussed. It was concluded that the description texts in the ICDE database should be searched for related keywords as well as events with associated root cause and/or coupling factor. Consequently, the brainstorming resulted in 20 keywords related to events due to external environmental factors which were filtered for in the field C5 - Event description, respectively C7 – Interpretation: "clog", "damp", "debris", "earthquake", "eel", "environment", "flood", "foam", "frazile", "freez", "freeze", "low temp", "moisture", "pollution", "sludge", "sludge/mussels", "snow", "storm", "temperature" and "weather". The same events were found for several keywords. In addition, events which were coded with root cause "Abnormal environmental stress" and/or coupling factor "Environmental external" were also considered.

The search resulted in finding 70 potential events where 58 events were considered to be caused by external factors. Among these, additional 6 events were excluded from the scope due to lack of information in the event descriptions. Consequently, 52 events were presented to the ICDE Steering Group as the workshop scope. However, during the workshop 9 events (work event B9, C3, C4, C9, D1, D7, E1, E7, E10 in Table 1) were pointed out as not being events due to external factors and were therefore removed from the scope of the workshop.

The process is illustrated in Figure 1.

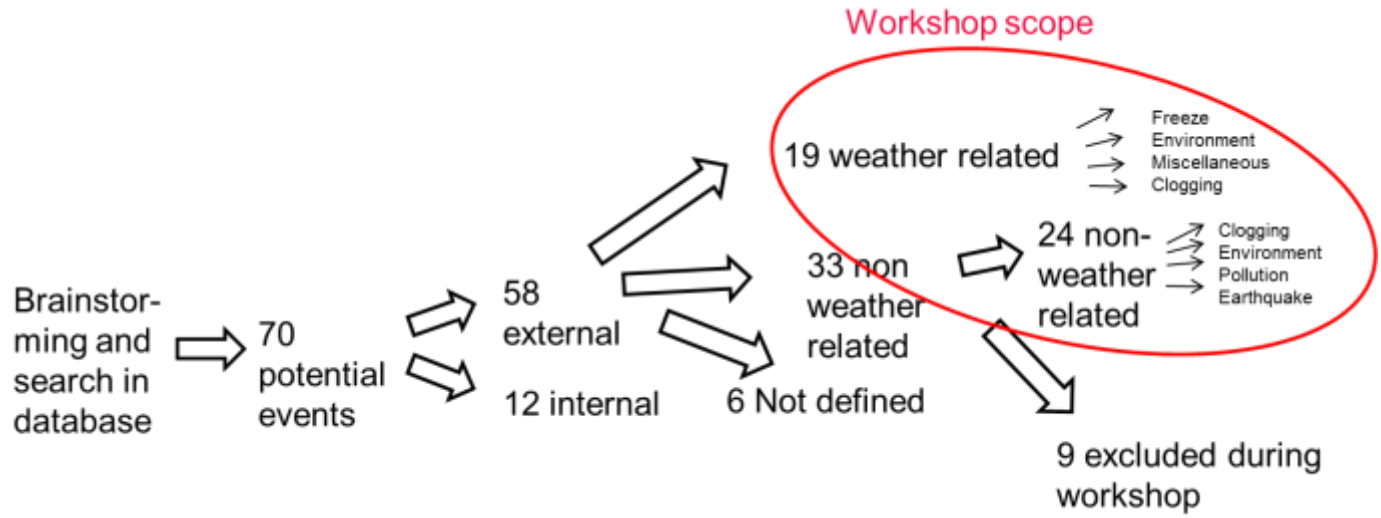

Figure 1 Preparation of event data "external factors"

3. OVERVIEW OF DATABASE CONTENT

3.1 Overview

The scope is to analyse events due to external factors like storms, hurricanes, extreme outdoor temperatures, excessive algae growth, extreme tide levels, sand accumulation, and also in combination of such factors. Of the concluded 43 events 19 were caused by extreme weather conditions and 24 were caused by physical phenomena unrelated to weather conditions, for example clogging by sand or algae or other pollution effects and earthquake.

The scope of the workshop is summarised in Table 1. When assigning the events to the work groups, the aim was to let each group analyse the same kind of events (weather relation and physical phenomena) in order to facilitate the analysis process. The 9 events removed during the workshop are not included further in this report.

Table 1 Overview of the ICDE events due to external factors

Group	Physical phenomena	Component type	Component Impairment Vector[1]	Work event	Comment
Weather	Freeze	Diesel	CI	A3	
		Centrifugal Pump	CC	A1	
			CCCC	A2	
			CDWW	A4	
	Miscellaneous	Diesel	CCWWW	A6	
			CD	A7	
			DDII	A9	
			IIII	A8	
		Centrifugal Pump	DDDDDDDD	A10	
			DDWW	A5	
	Clogging	Centrifugal Pump	CC	B1	
				B2	
		Heat Exchanger	CDII	B3	
			DD	B4	
				B5	
				B6	
				B7	
			DDWW	B8	
	Environment	Centrifugal Pump	CDDD	A11	
Non-weather related	Pollution	Centrifugal Pump	IIWW	B9	Removed during workshop
	Earthquake	Battery	IIIIWW	B10	
	Clogging	Diesel	CCWW	C4	Removed during workshop
			CDWW	D4	
			CI	D9	

1 The impairment vector presents the impairment status of each component of the Exposed population. C = Complete failure of the component to perform its function, D = Degraded ability of the component to perform its function, I = Incipient failure of the component and W = Component is working according to specification [2]

Group	Physical phenomena	Component type	Component Impairment Vector[1]	Work event	Comment
Non-weather related	Clogging	Diesel	DD	C6	
				E2	
			DDWW	C9	Removed during workshop
			DI	C2	
			IIIW	E3	
			IIWW	D2	
				D5	
		Centrifugal Pump	CC	D3	
				D6	
			CCI	D1	Removed during workshop
			CCII	E6	
			CCWWWW	C1	
			CDWWWW	E1	Removed during workshop
			DDWWW	C7	
			III	C10	
				C5	
		Level measurement	2 C, 10 W	D7	Removed during workshop
		Heat Exchanger	CCWW	D8	
			DD	C8	
				D10	
				E5	
			DDI	E4	
		Safety and Relief Valve	3 I, 17 W	C3	Removed during workshop
	Environment	Centrifugal Pump	CC	E11	
			CCW	E10	Removed during workshop
			CCWWWW	E7	Removed during workshop
			IIWW	E8	
		Safety and Relief Valve	CCI	E9	

Table 2 and Figure 2 show the distribution of the events by component types. The components most susceptible to failures due to external factors are pumps, followed by diesels and heat exchangers. The occurred failure modes per component type can also be found in Table 2 and the distribution of the failure modes are presented in Figure 2.

Table 2 Distribution of component types

Component type	No. of Events	Percent	Occurred failure modes
Battery	1	2,3%	Failure to run
Centrifugal Pump	17	39,5%	Failure to run Failure to start
Diesel	13	30,2%	Failure to run Failure to start
Heat Exchanger	11	25,6%	Failure of heat transfer
Safety and Relief Valve	1	2,3%	Failure to open
Total	**43**	**100,0%**	

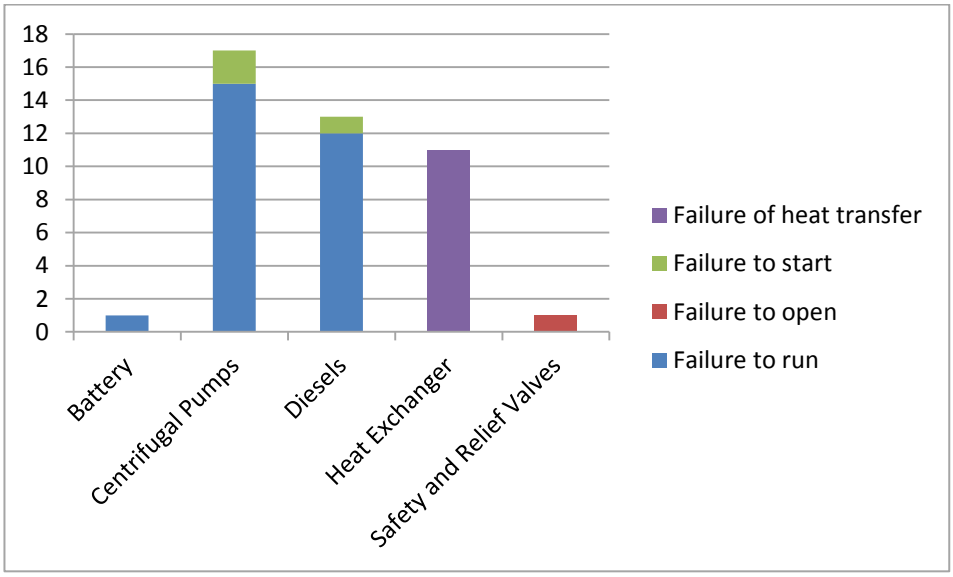

Figure 2 Distribution of component types and failure modes per component type

3.2 Root Causes

The ICDE general coding guidelines [2] define root cause as follows. The cause field identifies the most basic reason for the component's failure. Most failure reports address an immediate cause and an underlying cause. For this project, the appropriate code is the one representing the common-cause, or if all levels of causes are common-cause, the most readily identifiable cause. The following coding was suggested:

C State of other components. The cause of the state of the component under consideration is due to state of another component.

D Design, manufacture or construction inadequacy. This category encompasses actions and decisions taken during design, manufacture, or installation of components, both before and after the plant is operational. Included in the design process are the equipment and system specification, material specification, and initial construction that would not be considered a maintenance function. This category also includes design modifications.

A Abnormal environmental stress. This represents causes related to a harsh environment that is not within component design specifications. Specific mechanisms include chemical reactions, electromagnetic interference, fire/smoke, impact loads, moisture, radiation, abnormally high or low temperature, vibration load, and severe natural events.

H Human actions. This represents causes related to errors of omission or commission on the part of plant staff or contractor staff. This category includes accidental actions, and failure to follow procedures for construction, modification, operation, maintenance, calibration, and testing. This category also includes deficient training.

M Maintenance. All maintenance not captured by H – human actions or P – procedure inadequacy.

I Internal to component or piece part. This deals with malfunctioning of internal parts to the component. Internal causes result from phenomena such as normal wear or other intrinsic failure mechanisms. It includes the influence of the environment on the component. Specific mechanisms include corrosion/erosion, internal contamination, fatigue, and wear out/end of life.

P Procedure inadequacy. Refers to ambiguity, incompleteness, or error in procedures, for operation and maintenance of equipment. This includes inadequacy in construction, modification, administrative, operational, maintenance, test and calibration procedures. This can also include the administrative control procedures, such as change control.

O Other. The cause of event is known, but does not fit in one of the other categories.

U Unknown. This category is used when the cause of the component state cannot be identified.

Table 3 and Figure 3 show the distribution of the events by root causes. The dominant root causes for all external CCF events are "Abnormal environmental stress" (A) and "Design, manufacture or construction inadequacy" (D). They account for 47% (A) and 30% (D) of the failure events, respectively. Many of the events with "Abnormal environmental stress" root causes involve debris, algae or mussels causing pumps, heat exchangers or the diesel's coolers to fail due to clogging.

Table 3 Distribution of external factor root causes

Code	Description	No. of Events	Percent
A	Abnormal environmental stress	20	46,5%
C	State of other component(s)	1	2,3%
D	Design, manufacture or construction inadequacy	13	30,2%
H	Human actions, plant staff	2	4,7%
I	Internal to component, piece part	3	7,0%
P	Procedure inadequacy	3	7,0%
U	Unknown	1	2,3%
	Total	**43**	**100%**

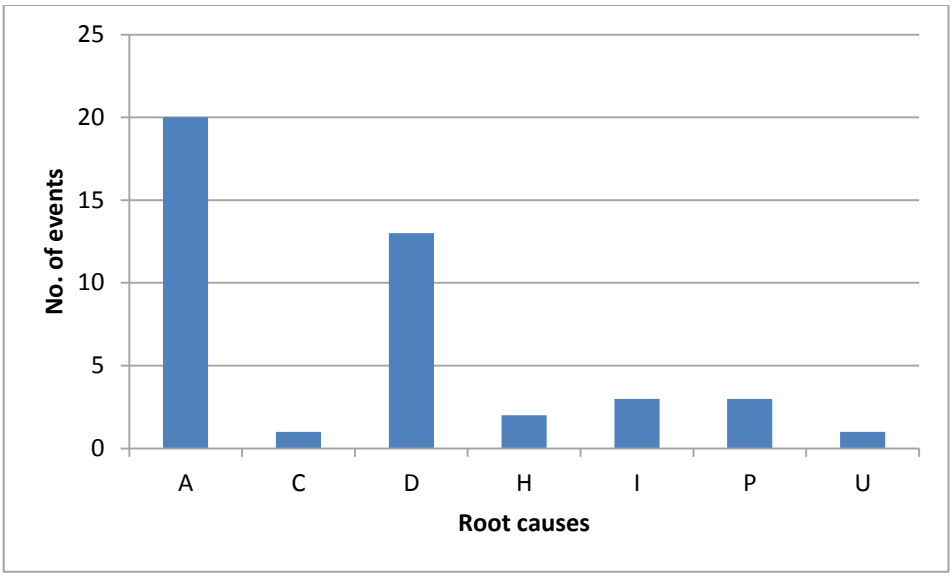

Figure 3 Distribution of external factor root causes

3.3 Coupling Factors

The ICDE general coding guidelines [2] define coupling factor as follows. The coupling factor field describes the mechanism that ties multiple impairments together and identifies the influences that created the conditions for multiple components to be affected. For some events, the root cause and the coupling factor are broadly similar, with the combination of coding serving to give more detail as to the causal mechanisms.

Selection is made from the following codes:

H Hardware (component, system configuration, manufacturing quality, installation, configuration quality). Coded if none of or more than one of HC, HS or HQ applies, or if there is not enough information to identify the specific 'hardware' coupling factor.

HC Hardware design. Components share the same design and internal parts.

HS System design. The CCF event is the result of design features within the system in which the components are located.

HQ Hardware quality deficiency. Components share hardware quality deficiencies from the manufacturing process. Components share installation or construction features, from initial installation, construction, or subsequent modifications

O Operational (maintenance/test (M/T) schedule, M/T procedures, M/T staff, operation procedure, operation staff). Coded if none or more than one of OMS, OMP, OMF, OP or OF applies, or if there is not enough information to identify the specific 'maintenance or operation' coupling factor.

OMS M/T schedule. Components share maintenance and test schedules. For example the component failed because maintenance procedure was delayed until failure.

OMP M/T procedure. Components are affected by the same inadequate maintenance or test procedure. For example, the component failed because the maintenance procedure was incorrect or calibration set point was incorrectly specified.

OMF M/T staff. Components are affected by maintenance staff error.

OP Operation procedure. Components are affected by inadequate operations procedure.

OF Operation staff. Components are affected by the same operations staff personnel error.

E Environmental, internal and external.

EI Environmental internal. Components share the same internal environment. For example, the process fluid flowing through the component was too hot.

EE Environmental external. Components share the same external environment. For example, the room that contains the components was too hot.

U Unknown. Sufficient information was not available in the event report to determine a definitive coupling factor.

These codes are grouped into the following coupling factor category groups:

- Environmental: E, EE, EI
- Hardware: H, HC, HS, HQ
- Operations: O, OMF, OMP, OP, OF, OMS

Table 4 and Figure 4 show the distribution of the failure events by coupling factor. The dominant coupling factor category group is as expected "Environment", which accounts for almost 51% of the events due to external factors.

The highest coupling factor is "Environment External" with 26% of the events. Many of the events with "Environment External" coupling factors involve extreme outdoor temperature affecting several components and causing multiple failures. Examples are low outdoor temperature causing non operable diesels due to too cold diesel oil temperatures and high outdoor temperatures causing extreme algae growth and clogging of heat exchangers.

Table 4 Distribution of external factor coupling factors

Code	Description	No. of Events	Percent
Environment		**22**	**51,2%**
E	Environment (internal, external)	7	16,3%
EE	Environment External	11	25,6%
EI	Environment Internal	4	9,3%
Hardware		**15**	**34,9%**

Code	Description	No. of Events	Percent
H	Hardware (component part, system configuration, manufacturing quality, installation/configuration quality)	2	4,7%
HC	Hardware Design	1	2,3%
HS	System Design	12	27,9%
Operations		**6**	**14,0%**
O	Operational (maintenance/test (M/T) schedule, M/T procedure, M/T staff, operation procedure, operation staff)	2	4,7%
OMF	Maintenance/test Staff	1	2,3%
OMP	Maintenance/test Procedure	3	7,0%
Total		**43**	**100%**

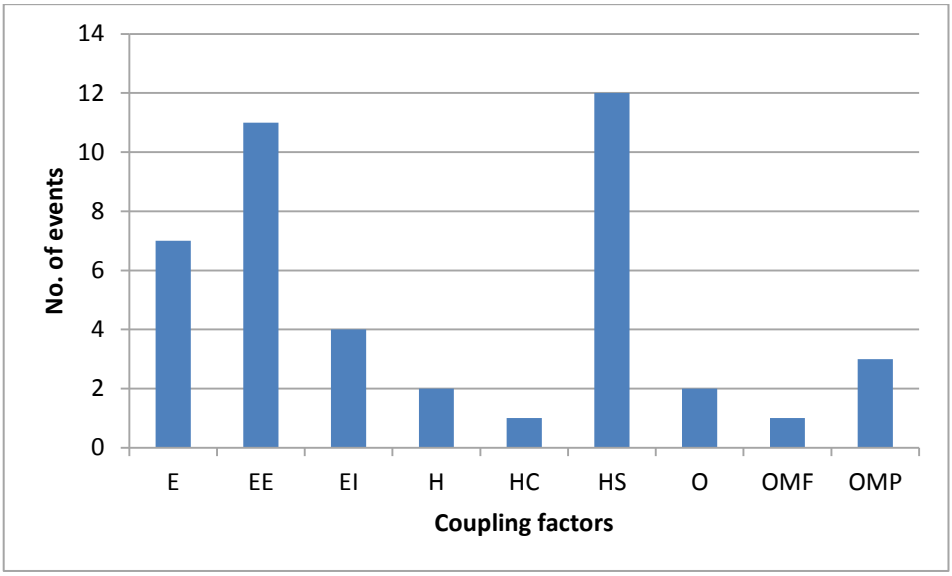

Figure 4 Distribution of external factor coupling factors

3.4 Detection Method

The ICDE general coding guidelines [2] suggest the following coding for the detection method for each failed component of the exposed population:

MWmonitoring on walkdown

MC monitoring in control room

MA maintenance/test

DE demand event (failure when the response of the component(s) is required)

TI test during operation

TA test during annual overhaul

TL test during laboratory

TU unscheduled test

U unknown

Table 5 and Figure 5 contain the distribution of the events due to external factors by detection method. Demand was the main way of detecting external problems, followed by test during operation. The high number of demand events suggests that these types of "external failures" may be difficult to detect in periodic tests.

Table 5 Distribution of external factor detection modes

Code	Description	No. of Events	Percent
DE	Demand	16	37,2%
MA	Maintenance/Test	7	16,3%
MC	Monitoring in Control Room	6	14,0%
MW	Monitoring on Walkdown	3	7,0%
TI	Test during operation	9	20,9%
U	Unknown	2	4,7%
	Total	**43**	**100%**

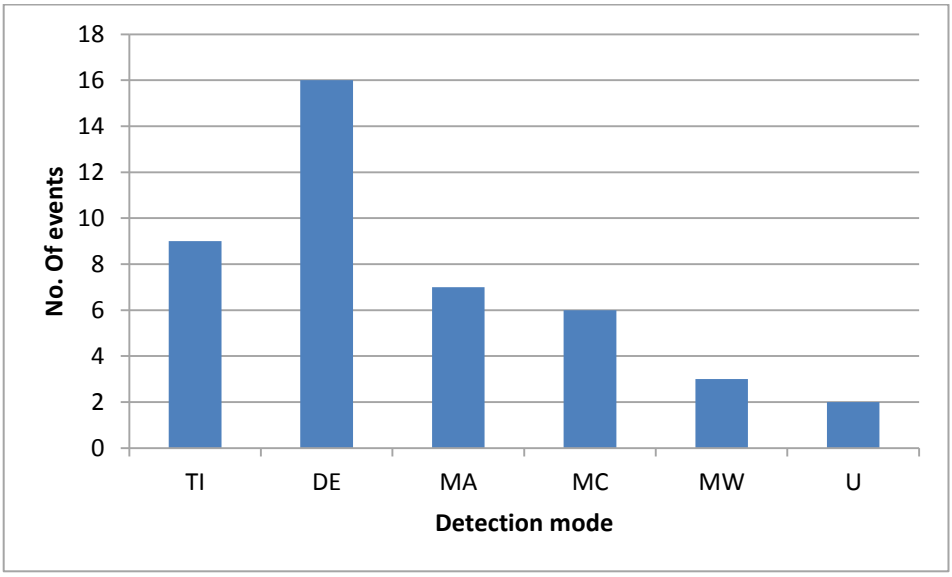

Figure 5 Distribution of external factor detection modes

Moreover, if grouping the detection modes into "Test" (includes normal tests, i.e. TI and TA) and "Not test", it can be seen that 34 events (79%) are not detected by normal tests.

3.5 Corrective Actions

The ICDE general coding guidelines [2] define corrective action as follows. The corrective actions field describes the actions taken by the licensee to prevent the CCF event from reoccurring. The defence mechanism selection is based on an assessment of the root cause and/or coupling factor between impairments.

Selection is made from the following codes:

A. General administrative/procedure controls

B. Specific maintenance/operation practices

C. Design modifications

D. Diversity. This includes diversity in equipment, types of equipment, procedures, equipment functions, manufacturers, suppliers, personnel, etc.

E. Functional/spatial separation. Modification of the equipment barrier (functional and/or physical interconnections). Physical restriction, barrier, or separation.

F. Test and maintenance policies. Maintenance program modification. The modification includes item such as staggered testing and maintenance/ operation staff diversity.

G. Fixing component

O. Other. The corrective action is not included in the classification scheme.

The distribution of the events for corrective actions is shown in Table 6 and Figure 6. 35% of the corrective actions are of the type "Specific maintenance/operation practices" (B), followed by "Design modifications" (C).

Table 6 Distribution of external factor corrective actions

Code	Description	No.	Percent
A	General administrative/procedure controls	5	11,6%
B	Specific maintenance/operation practices	15	34,9%
C	Design modifications	10	23,3%
E	Functional/spatial separation	4	9,3%
F	Test and maintenance policies	4	9,3%
G	Fixing of component	2	4,7%
O	Other	2	4,7%
	Empty	1	2,3%
	Total	**43**	**100%**

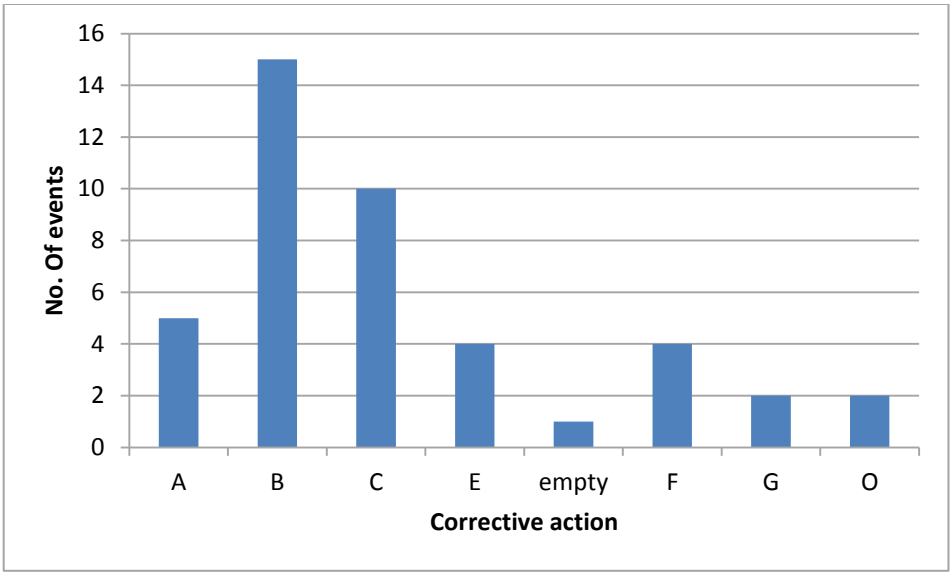

Figure 6 Distribution of external factor corrective actions

4. ENGINEERING ASPECTS OF THE COLLECTED EVENTS

This section contains an engineering review of the events due to External factors.

The analysis was based on questions listed in the workshop form, see Appendix C. The participants were also asked to mark interesting events according to the suggested codes, see Appendix D. This marking procedure was a new concept in the project and was introduced and tried for the first time during the workshop.

4.1 Identified failure mechanisms, areas of improvement and lessons learnt

In this section the most interesting and representative failure mechanisms identified during the workshop are described. These descriptions are sorted by the corresponding areas of improvement and lessons learnt. Table 8 lists representative failure mechanisms sorted by component type.

Table 7 Representative failure mechanisms sorted by component type

Component type	Occurred failure mechanisms
Battery	- Potential loss of function during earthquake due to cracks in battery casings
Centrifugal Pump	- Freezing led to blocking by ice of suction lines of service water pumps - Heavy seaweed accumulation in combination with low tide caused lack of water - Excessive sand and shellfish in sea water led to wear of pump impeller - Sandy water intrusion and corrosion products lead to clogging of bearing lube water lines - Extremely low level of sea water was not considered in design - Algae growth in diesel fuel tank led to failure of operation of diesel driven pumps
Diesel	- Sludge in sea water reduced cooling capacity - Excessive sand and shellfish in sea water led to clogging of heat exchangers
Heat Exchanger	- High temperatures led to fast growth of clams and mussels with subsequent clogging of heat exchangers - Very high water level in combination with highly polluted water (foliage and grass) led to clogging of heat exchangers
Safety and Relief Valve	- Diaphragms installed in the air supply regulators of safety relief valves were dry and cracked due to long term high temperature environment leading to failure to open of the valves

The identified areas of improvements and lessons learnt can be divided into two subcategories - human/operational and hardware related improvements. Examples of typical events involving these improvements are presented in the following.

Human and operational related improvements

"Increased monitoring" was one of the most common type of operational improvements which was concluded for events involving pumps, diesels and heat exchangers. "Increased monitoring" involves more frequent monitoring or more efficient monitoring techniques. For one pump event (work event A2) the service water pumps failed to operate due to freezing of several lines. Here more frequent monitoring of suction lines in case of freezing temperatures could have prevented the event from happening. The same improvement, more frequent monitoring of the water flow rate and temperature conditions, was identified for one diesel event (work event D2) where sludge in the sea water led to reduced cooling capacity and therefore too high temperatures of the diesel´s cooling water. There are three events (work events E3, E5, E8) where the surveillance procedure was identified to be a successful defence. All three events involve slow processes where excessive sand or shellfish in the sea water causes wear of the pump´s impeller or clogging in the heat exchanger. Due to the slowly developing failure, it was possible to detect the event with differential pressure monitoring before degradation of the pump or heat exchanger.

Also "improved cleaning of strainers" was concluded as an important improvement for events involving pumps, diesels and heat exchangers, with the majority representing heat exchanger events. All five heat exchanger events (work events B4-B8) involved high sea water temperatures leading to fast growth of clams and mussels and simultaneously clogging of the heat exchangers. Improved procedures were identified to be important, along with enhanced monitoring capability. One pump event (work event B2) was due to correlated hazards – unusually heavy seaweed in combination with low tide causing lack of water for the pumps in the sea water intake. Again, improved cleaning of the strainers (for example addition of backflush capability), could have prevented the event from happening.

Three diesel events within three years (work events D2, D4, D5) at the same site experiencing the same failure mechanism are proof that back fitting of operational experience takes a long time. These events involved sludge in the sea water leading to reduced cooling capacity and therefore to too high temperatures of the diesel´s cooling water. Here it could be concluded that thorough root cause identification before continuation of operation is crucial to prevent repetitions of the failure.

Hardware related improvements

Since many of the events due to external factors involve sea water problems, important hardware improvements involve design changes of the water intake. One pump event revealed that there had been insufficient attention to possible low level of sea water (work event A11). The same diesel event mentioned above (work event D2), where sludge in the sea water led to reduced cooling capacity and therefore to too high temperatures of the diesel´s cooling water, could have been prevented if the water intake had been diversified. An example of a diversified water intake could be one surface intake and one deep water intake. Another interesting event was a pump event (work event E11) where both emergency feed water pumps driven by diesel engines were degraded due to algae growth in the shared diesel fuel tank. The shared fuel tank is an example of not fully implemented separation of redundant pumps.

However, even though hardware related improvements appear to be the most appropriate way of improvement, it is important to identify the actual root cause before taking actions. One example (work event E3) where it is unclear if the corrected action actually addressed the root cause is the diesel event

where sludge in the sea water led to reduced cooling capacity and therefore to too high temperatures of the diesel´s cooling water. The problem was corrected by installing new mussel strainers.

4.2 Other aspects of interest

Two interesting aspects can be mentioned here. The first involves correlated hazards, which should be taken into account for better defence. There is one heat exchanger event (work event B3) where very high water level in combination with high amount of pollution in water such as foliage and grass led to clogging of the tubes in the heat exchangers. The second interesting aspect is related to a question in the workshop form "Try to continue the sentence *Nothing happened because…*". Here one service water pump event (work event C5) was concluded as "slight impairment by chance" because the detection of low backup seal water supply was not via monitoring of the flow but by testing of the seal water regulator of the pumps with isolated main seal water supply after outage. The sea water flow to the pump was slowly decreasing due to clogging of the water lines, which were caused by sand from the sea and corrosion products. If the failure progression had been faster, a more severe failure could have occurred before the previous outage in case of unavailable main seal water supply. Additionally, this event also emphasises the above mentioned observation that back fitting of operational experience takes a long time as four weeks after the first findings, one additional service water pump had been declared out of service when seal water supply was below the required minimum flow rate due to clogging by sand and corrosion products.

4.3 Marking of interesting events

Marking of interesting events in the ICDE database consists of identifying interesting and extra ordinary CCF events by specific codes and descriptions, for example events where components in more than one group of components or more than one plant were affected by the same failure mechanism (see Appendix D). The identification of important dependency events can provide useful information for the overall operating experience and can also be used as input to pre-defined processes at the utilities.

For many of the events due to external factors analysed during the workshop it was possible to apply the "interesting CCF event codes" according to Appendix D. It resulted in 7 out of the 11 codes being applied in total, see Table 8. One event was marked with several codes. The most popular code was "CCF Fleet impact". This code was assigned to 10 events and 5 of these events involved failure mechanisms that had occurred at several units at the same site. Consequently, it was suggested to divide this CCF event code into two subgroups; same failure mechanism in several plants at the *same* site and same failure mechanism in several plants at *different* sites.

Table 8 Applied interesting event codes

Interesting CCF event code	Description	No. of events
CCF Complete	Complete failure of all components	4
CCF Outside planned test	The event was detected outside normal or periodic test	5
CCF Comp not-capable	A set of components was not capable to perform its safety function over a long period of time.	0
CCF Def-multi	Two or more defence in depth levels were affected	0
CCF New-failure mechanism	Unattended or not foreseen failure mechanism	4
CCF Different CCF sequence	Sequence of different CCF failures and/or subtle dependencies	0
CCF Causes modification	Event causes major modification, e.g. exchange of diesel	1
CCF Intersystem dependency	Event affecting two or more different systems or functions	1
CCF IE CCI	Event which is both a CCF event and a initiating event causing loss of needed safety system	0
CCF Fleet impact	Failure mechanism appeared in several plants	10
CCF Safety Culture	Reason of event originates from safety culture management	1

5. SUMMARY AND CONCLUSIONS

The scope of this report includes 43 ICDE events. These reported events were reviewed in Sections 3 and 4 with respect to degree of failure, failure causes and failure mechanism. During the review the scope was discussed and it was concluded that the scope "events due to external factors" was hard to define. Eventually, it was determined that the scope was to analyse events due to external factors, like storms, hurricanes, extreme outdoor temperatures, excessive algae growth, extreme tide levels, sand accumulation, also in combination of such factors. Of the included 43 events 19 were caused by extreme weather conditions and 24 were caused by physical phenomena unrelated to weather conditions, for example, clogging by sand or algae or other pollution effects, earthquake. During the workshop 9 events were found not to be due to external factors and are therefore not addressed further in this report. The scope of the analysed events indicates that the components most susceptible to failures due to external factors are pumps, followed by diesels and heat exchangers.

The report includes several suggested improvements and lessons learnt and other interesting insights. To make it easier to interpret and learn from the inferred conclusions, typical examples of events and their failure mechanisms along with the concluded improvements are presented.

In the workshop also some general interesting aspects were identified. E.g. there were some events which were not detected by regular tests and the observed impairments could have developed to more severe failures if not detected. Another example is the appearance of some recurrent events which indicates that back fitting of operating experience sometimes takes too long to avoid recurrence of the same kind of events.

Marking of interesting events in the ICDE database was a new concept in the project and was introduced and tested for the first time during this workshop. This concept turned out to be useful and a couple of interesting events were identified. Further application is still needed in order to evaluate and develop the codes further.

The results of this analysis may serve as input for an in depth review of the methods and assumptions used in external hazards PSA. A discussion on such reassessment of external hazards has started in the international community after the experience of the TEPCO Fukushima accident; see e.g. the PSAM 11 paper [3]. The aim of this research is to identify possible "external events" which may have low frequencies but large consequences or which may result from combinations of different impacts not yet considered in current external hazards PSA.

6. REFERENCES

1. Fukushima Daiichi Nuclear Power Station Accident - Summary of NEA and Members Response, Nuclear Energy Agency, Draft 7, June 2013

2. International Common-Cause Failure Data Exchange ICDE General Coding Guidelines ICDE CG00, CSNI Tech Note publication NEA/CSNI/R(2004)4. Rev. 2, October 2005.

3. "An Impact-based Approach in Selecting External Events for PRA at a NPP", Y. Narumiya et al. (PSAM 11 paper.)

APPENDIX A – OVERVIEW OF THE ICDE PROJECT

Appendix A contains information regarding the ICDE project.

A.1 Background

Common-cause failure (CCF) events can significantly impact the availability of safety systems of nuclear power plants. In recognition of this, CCF data are systematically being collected and analyzed in several countries. A serious obstacle to the use of national qualitative and quantitative data collections by other countries is that the criteria and interpretations applied in the collection and analysis of events and data differ among the various countries. A further impediment is that descriptions of reported events and their root causes and coupling factors, which are important to the assessment of the events, are usually written in the native language of the countries where the events were observed.

To overcome these obstacles, the preparation for the international common-cause data exchange (ICDE) project was initiated in August of 1994. Since April 1998 the NEA has formally operated the project, following which the Project was successfully operated over five consecutive terms from 1998 to 2011. The current phase started in 2011 and is due to run until 2014. Member countries under the current Agreement of NEA and the organisations representing them in the project are: Canada (CNSC), Czech Republic (NRI), Finland (STUK), France (IRSN), Germany (GRS), Japan (JNES), Korea (KAERI), Spain (CSN), Sweden (SSM), Switzerland (ENSI), United Kingdom (ONR), and United States (NRC).

More information about the ICDE project can be found at NEA´s web site: http://www.nea.fr/html/jointproj/icde.html. Additional information can also be found at the web site http://www.eskonsult.se/ICDE/.

A.2 Scope of the ICDE Project

The ICDE Project aims to include all possible events of interest, comprising complete, partial, and incipient CCF events, called ‘ICDE events’ in this report. The project covers the key components of the main safety systems, including centrifugal pumps, diesel generators, motor operated valves, power operated relief valves, safety relief valves, check valves, main steam isolation valves, fans, batteries, control rod drive assemblies, circuit breakers, level measurement and digital I&C equipment.

A.3 Data Collection Status

Data are collected in an MS.NET based database implemented and maintained at ES-Konsult, Sweden, the appointed ICDE Operating Agent. The database is regularly updated. It is operated by the Operating Agent following the decisions of the ICDE Steering Group.

A.4 ICDE Coding Format and Coding Guidelines

Data collection guidelines have been developed during the project and are continually revised. They describe the methods and documentation requirements necessary for the development of the ICDE databases and reports. The format for data collection is described in

the general coding guidelines and in the component specific guidelines. Component specific guidelines are developed for all analysed component types as the ICDE plans evolve [2].

A.5 Protection of Proprietary Rights

Procedures for protecting confidential information have been developed and are documented in the Terms and Conditions of the ICDE project. The co-ordinators in the participating countries are responsible for maintaining proprietary rights. The data collected in the database are password protected and are only available to ICDE participants who have provided data.

APPENDIX B – DEFINITION OF COMMON-CAUSE EVENTS

In the modelling of common-cause failures in systems consisting of several redundant components, two kinds of events are distinguished:

- Unavailability of a specific set of components of the system, due to a common dependency, for example on a support function. If such dependencies are known, they can be explicitly modelled in a PSA.

- Unavailability of a specific set of components of the system due to shared causes that are not explicitly represented in the system logic model. Such events are also called 'residual' CCFs. They are incorporated in PSA analyses by parametric models.

There is no rigid borderline between the two types of CCF events. There are examples in the PSA literature of CCF events that are explicitly modelled in one PSA and are treated as residual CCF events in other PSAs (for example, CCF of auxiliary feed water pumps due to steam binding, resulting from leaking check valves).

Several definitions of CCF events can be found in the literature, for example, in NUREG/CR-6268, Revision 1 'Common-Cause Failure Data Collection and Analysis System: Event Data Collection, Classification, and Coding:'

Common-Cause Failure Event: A dependent failure in which two or more component fault states exist simultaneously, or within a short time interval, and are a direct result of a shared cause.

A CCF event consists of component failures that meet four criteria: (1) two or more individual components fail, are degraded (including failures during demand or in-service testing), or have deficiencies that would result in component failures if a demand signal had been received, (2) components fail within a selected period of time such that success of the probabilistic risk assessment (PRA) mission would be uncertain, (3) components fail because of a single shared cause and coupling mechanism, and (4) components fail within the established component boundary.

In the context of the data collection part of the ICDE project, focus will be on CCF events with total as well as partial component failures that exist over a relevant time interval[2]. To aid in this effort the following attributes are chosen for the component fault states, also called impairments or degradations:

- Complete failure of the component to perform its function

- Degraded ability of the component to perform its function

- Incipient failure of the component

2 Relevant time interval: two pertinent inspection periods (for the particular impairment) or, if unknown, a scheduled outage period.

- Default: component is working according to specification

Complete CCF events are of particular interest. A ‘complete CCF event’ is defined as a dependent failure of all components of an exposed population where the fault state of each of its components is ‘complete failure to perform its function’ and where these fault states exist simultaneously and are the direct result of a shared cause. Thus, in the ICDE project, we are interested in collecting complete CCF events as well as partial CCF events. The ICDE data analysts may add interesting events that fall outside the ICDE event definition but are examples of recurrent - eventually non random - failures.

With growing understanding of CCF events, the relative share of events that can only be modelled as ‘residual’ CCF events is expected to decrease.

APPENDIX C – WORKSHOP FORM

C.1 Main areas of improvement?

- Can any areas of improvement be identified in order to prevent the event from happening again?
- What could have prevented the event from developing into a more severe event (i.e. Complete[5] or Partial[6] CCF event)? Try to continue the sentence "Much happened because…"

Examples of conclusions:

– The event developed slowly during plant operation, creating degraded or fault conditions of components. Much happened because of incomplete operating and maintenance procedures.

– Area of improvement: Ensuring comprehensive work control

– Area of improvement: Better planning of tests/maintenance.

– Area of improvement: Comprehensively prescribing the steps of testing required in the re-qualification of components or systems after maintenance, repair or backfitting work.

C.2 Lessons learnt?

- Can any general lessons be concluded regarding the event?
- Does the less severe events (CCF impaired[3] or Complete impairment[4]) contain any specific factor or defence preventing it from being a more severe event (i.e. Complete[5] or Partial[6] CCF event)? Try to continue the sentence "Nothing happened because…"

Examples of conclusions:

– Nothing happened because of chosen testing technique.

– The types of failures are extremely random which indicates difficulties in identifying specific important defence factors. Hence, nothing happened because of luck?

3 CCF Impaired = At least one component in the Group is Completely failed and others affected (i.e. At least one C and at least one I or one D in the impairment vector, but not partial CCF or complete CCF.)

4 Complete impairment = All components in the exposed population are affected, no complete failures but complete impairment. Only incipient degraded or degraded components. (all D or I in the impairment vector).

5 Complete CCF = All components in the Group are completely failed (i.e. all elements in impairment vector are C, Time factor high and shared cause factor high.)

6 Partial CCF = At least two components in the Group are Completely failed (i.e. At least two C in the impairment vector, but not complete CCF. Time factor high and shared cause factor high.)

- General lesson: High redundancy is an effective defence against complete CCF. However, complete CCF cannot be prevented by high redundancy.

- General lesson: the higher the degree of redundancy, the more it takes human inadvertent action to fail the system.

C.3 Other aspects of interest

- Do you have any comments regarding the grouping of the event according to table 2.
- Have you found any new failure modes, unusual failure mechanisms or unusual ways of operation of value for the overall operating experience of the respective component?
- Other findings that are not yet taken care of in the coding guideline for respective component?
- At which operational mode is a failure discovered?
- Does the event report give enough qualitative information about – system configurations, FSAR or Technical Specification demands, other important information?

C.4 Comments on event coding

- Have you found any uncertainties regarding the event coding?
- Other findings that concern the coding of the event?

APPENDIX D – CODES FOR MARKING INTERESTING EVENTS

Interesting CCF event codes	**Description** ***Purpose***
CCF Complete	Event has led to a complete CCF. *This code sums up all complete CCF:s, for any component type.*
CCF Outside planned test	The CCF event was detected outside of normal periodic and planned testing and inspections. *The code gives information about test efficiency, when CCFs are observed by other means than periodic testing – information about weaknesses in the Defence in Depth level 2.*
CCF Comp not-capable	Event revealed that a set of components was not capable to perform its safety function over a long period of time. *The code gives information about a deviation from deterministic approaches, when it is revealed that two or more exposed components would not perform the licensed safety function during the mission time.*
CCF Def-multi	Several defences against CCF mechanisms are affected. *The code gives information about a deviation from deterministic approaches that two or more defence in depth levels are affected due to a CCF.*
CCF New-failure mechanism	Event revealed an unattended or not foreseen failure mechanism. *The code gives information about a new CCF event revealed a new failure mechanism, not earlier documented in the licensing documentation.*
CCF Different CCF sequence	Sequence of different CCF failure *The code gives information about a new type of CCF event with a new failure mechanism.*
CCF Causes modification	Event causes major modification *The code gives information about a CCF event revealed that has led to or will lead to a major plant modification.*
CCF Intersystem dependency	Intersystem dependency. *This indicator gives information about CCFs affecting two or more different systems / functions. The CCF event affects two or more components, functions belonging to several systems. Affected components to be estimated as an exposed population. Interesting deviation from deterministic approaches and operating experiences.*
CCF IE CCI	A dependency event originating from an initiating event of type common cause initiator (CCI) – a CCF event which is at the same time an initiator and a loss of a needed safety system. *The code gives information about an event with direct interrelations between the accident mitigation systems through common support systems. An event of interest for e.g., PSA analysts, regulators.*
CCF Fleet impact	The failure mechanism has appeared in several plants
CCF Safety Culture	The reason to why the event happened originates from safety culture management.