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Canada

Recent Insights from the International Common Cause Failure Data Exchange (ICDE) Project

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Canada

Outline

I. ICDE History
II. ICDE Objectives
III. ICDE Organization
IV. Data Collection Exchange
V. Data Current Status
VI. Technical Scope Current Status
VII. Lessons Learned
VIII. Conclusion

I. International Common Cause Failure Data Exchange (ICDE) History

- The ICDE project was initiated in August 1994
- Since April 1998, the OECD/NEA has formally operated the project
- ICDE defines the formats for collection of CCF events in order to arrive in a consistent database
- The ongoing ICDE project phase VIII covers the period 2019-2022

II. ICDE Objectives (1)

1. To provide a framework for an international co-operation
2. To collect and analyse CCF events on a long-term basis
3. To generate qualitative insights on root causes of CCF events

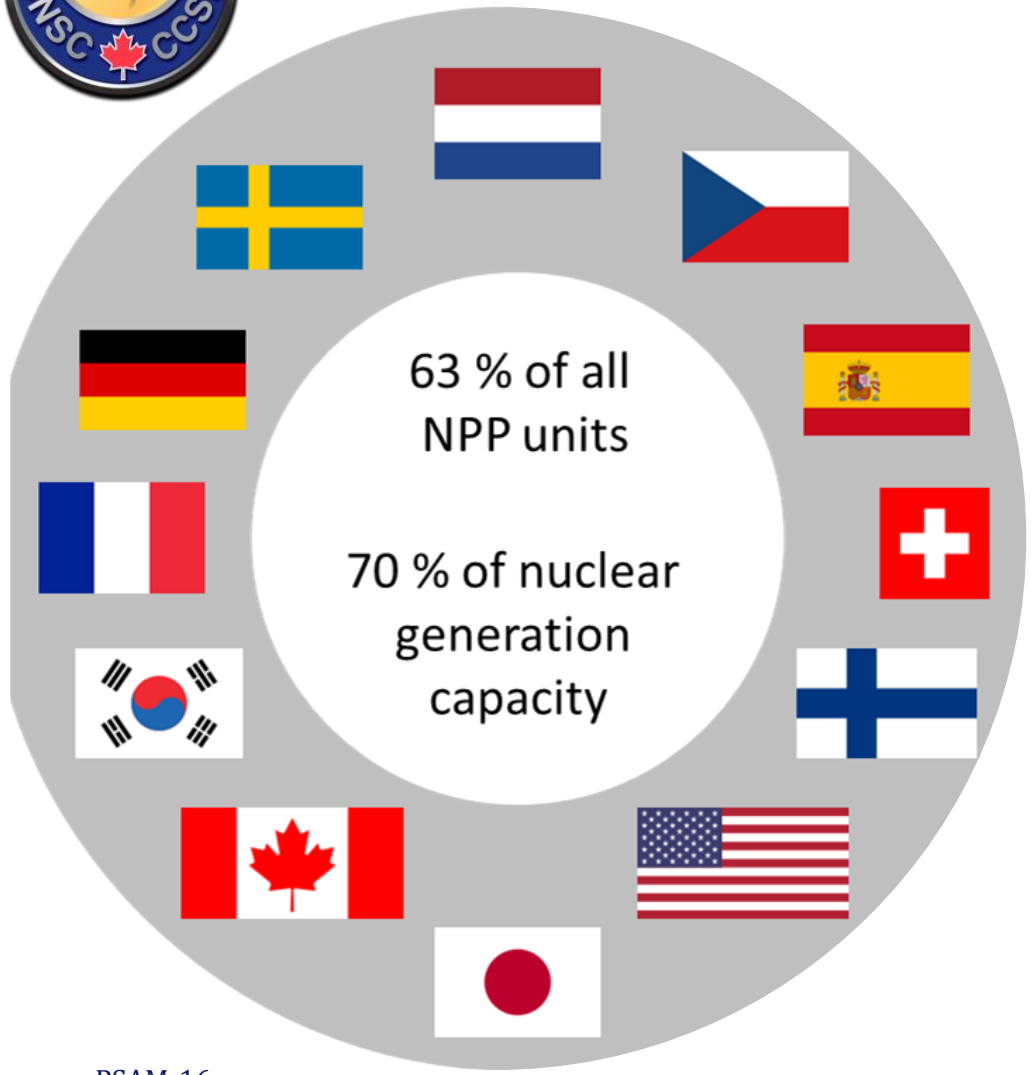
II. ICDE Objectives (2)

4. To establish a mechanism for the efficient feedback of experience gained in connection with CCF phenomena;

5. To generate quantitative insights/record event attributes to facilitate quantification of CCF frequencies; and

6. To use of ICDE data to estimate CCF parameters

III. ICDE Organization (1)



Participants in Phase VIII

- CNSC - Canada
- STUK - Finland
- IRSN - France
- GRS - Germany
- NRA - Japan
- KAERI - Republic of Korea (VII)
- ANVS - Netherlands
- SSM - Sweden
- ENSI - Switzerland
- NRC - United States
- UJV - Czech Republic

III. ICDE Organisation (2)

- Each participating country is represented by its national coordinator.
- The ICDE Steering Group (SG) controls the project, assisted by the NEA project secretary and the Operating Agent (OA).
- The OA is responsible for the database and consistency analysis.
- The ICDE SG responsibility to:
  - Define the priority of the task activities and to monitor the development of the project and task activities,
  - Secure the financial (approval of budget and accounts) and technical resources necessary to carry out the project

IV. Data Collection exchange (1): Definitions

Common Cause Failure Event:

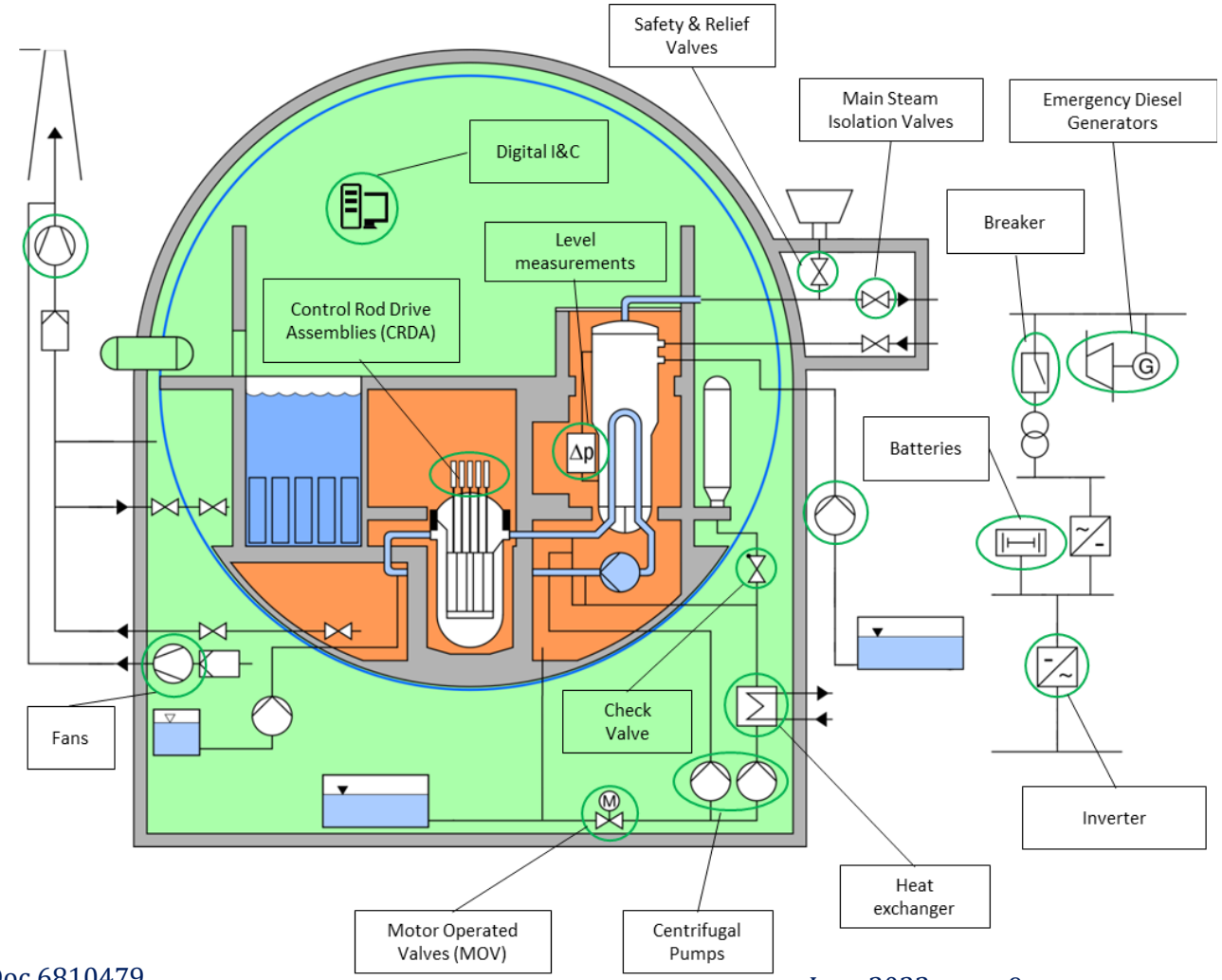
- **A dependent failure in which two or more component fault states exist simultaneously, or within a short time interval, and are a direct result of a shared cause.**
  - Complete CCF: All components failed completely
  - Partial CCF: At least two components failed completely
  - ICDE data collection includes also potential CCF events

ICDE Event

- **Impairment of two or more components (performing a specific function), which exists over a relevant time interval and is the direct result of a shared cause.**

IV. Data Collection exchange (2): ICDE Components

- Data collection is organized by component types
- Focus on active components
- Components type were added over time
  - Different amount of data for the individual types
- New types are added if necessary
  - Inverter are the latest addition



IV. Data Collection Exchange (3): In Practice

Data collection

- Data collection and analysis has to be organized on national levels.
- Operating experience (OPEX) is prepared by (or on behalf of) the participating organizations
  - Scope of necessary Information is defined in the “General Coding Guidelines”
- Prepared OPEX is send to the Operating Agent (OA) to integrate the new data in the central database
- Preparation of the OPEX is by far the most time-consuming part when participating in the ICDE project

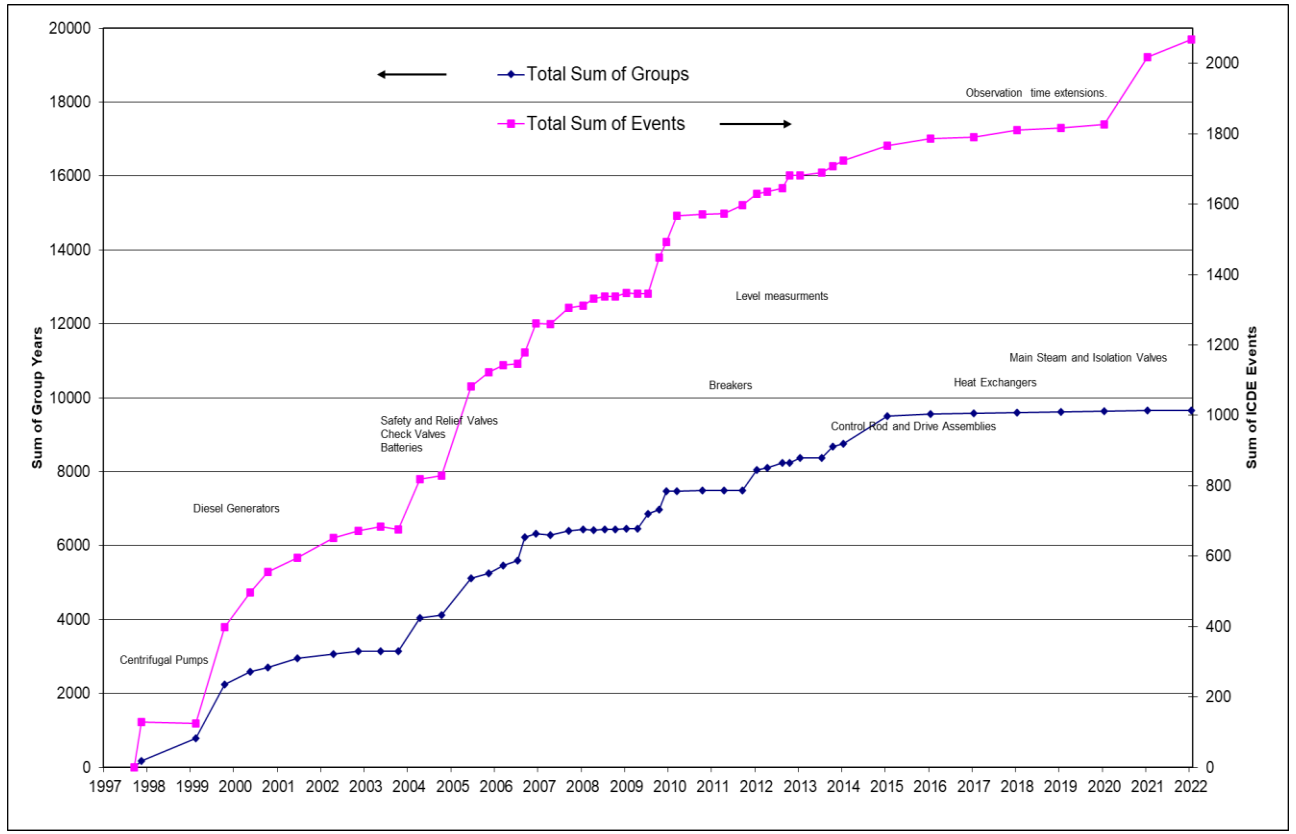
IV. Data Collection Exchange (1): In Practice

Data distribution

- The in-kind principle is followed
  - Data exchange means that each participant gets the dataset corresponding to its own data sent to ICDE
- Updated copies of the database (“replicas”) containing the amount of data to which the individual participating organization has the right to access are send out by the OA regularly

V. Data Current Status (1)

(ICDE Progress in 28 Years)



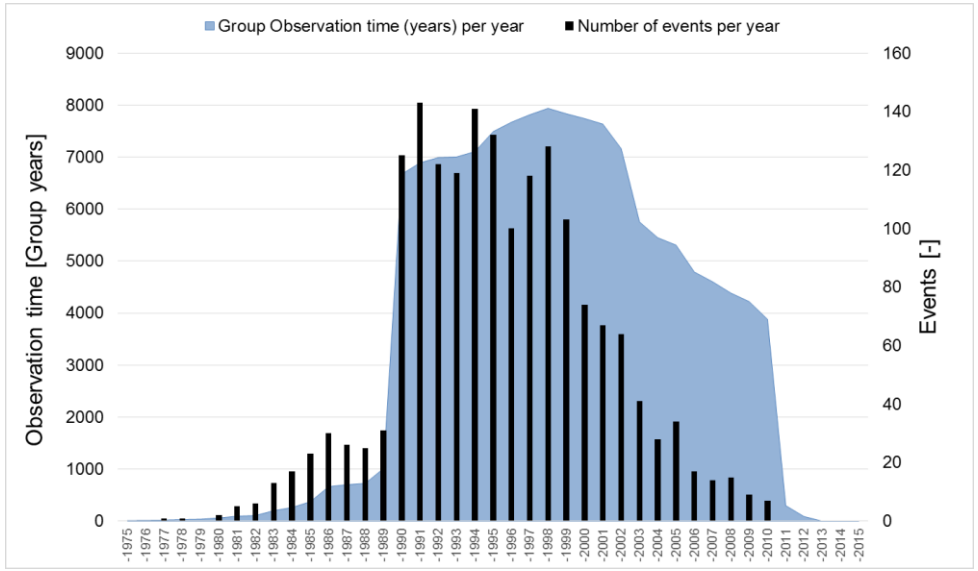
Database Content (March 2022)

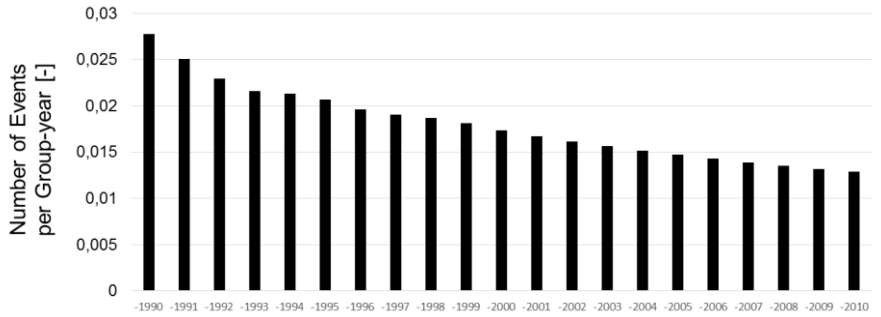
Component Type	Total CCF Event	Percentage (%)	Complete CCF	Partial CCF
Centrifugal Pumps	444	21.5	47	44
Diesels	348	16.8	33	21
Safety and Relief Valves	296	14.3	22	44
Motor Operated Valves	194	9.4	10	37
Control Rod Drive Assembly	180	8.7	4	27
Level measurement	169	8.2	9	32
Check valves	118	5.7	12	26
Breakers	116	5.6	6	29
Battery	87	4.2	5	2
Heat Exchanger	58	2.8	4	1
Fans	32	1.5	3	0
Main Steam Isolation Valves	13	0.6	1	4
Cross-component CCF	5	0.2	0	0
Digital I&C	4	0.2	2	0
Inverters	4	0.2	2	0
Grand Summaries	**2068**	**100%**	**160**	**267**

V. Data Current Status (2)

ICDE Observation Overview

- Number of Events per group-years dropped ~40 % (0,028 to 0,012) from its value in 1990
  - Measures to prevent CCF show effect
- But: Only a slow decay after 2000
  - Improved CCF prevention still important





VI. Technical Scope Current Status (1)

The ICDE Steering Group prepares publicly available reports

- Containing insights and conclusions from the analysis performed

whenever

- Major steps of the project have been completed, e. g.
  - analysis of a dataset for a certain component type or
  - a certain topic

VI. Technical Scope Current Status (2)

- **Data and publicly available component reports for :**
  - Centrifugal Pumps, Diesel Generators, Motor-Operated Valves, Safety Relief Valves, Check Valves, Batteries, Level Measurement, Breakers Control Rod Drive Assemblies, Heat Exchangers
- **Coding guidelines**
  - Includes Failure analysis guideline, Failure categorization from Component reports and Topical reports
- **Topical reports on CCF events**
  - External factors (2015, 43 events, updated in 2020 (64 events))
  - Emergency Diesel Generators with all redundant diesels affected (2017, 224 events)
  - Improving Testing (2019, 59 events)
  - Multi-unit events, (2019, 87 multi-unit events)
  - Plant modifications (2019, 54 events)
  - Inter-system dependencies (2020, 25 intersystem events)
  - Pre-initiator human failure (HFE) ICDE events (2022, 51 events)

VI. Technical Scope Current Status (3)

Ongoing data exchange

- Extended Observations times of “Old” Components
- Fans
- Digital I&C
- Inverters
- Cross component CCF: multiple component group CCF due to asymmetric electrical faults (in preparation)

Ongoing topical analyses

- Demand events
- Safety Culture events

Quantification Workshop based on case reports

- Case development ongoing for Batteries, Pumps Diesels
- Verification of data, Methods and assumptions

VII. Lessons learned (1):

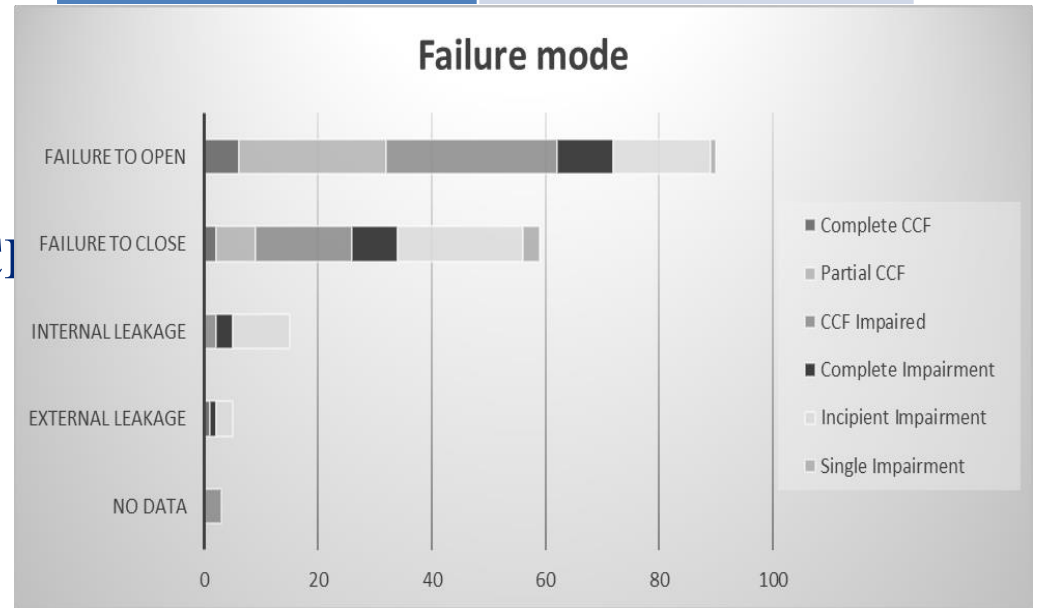
Example-1: Motor-Operated Valves CCF (1/3)

- **Objective:** update of the ICDE report on MOVs CCF events published in 2001 (87 events)

- **Observation :** Total of 172 Events
  - The most frequent failure mode is "failure to open" (52%).
  - Leakage, internal or external, has only occurred for about 12% of the events.
  - The most common event severity categories were "CCI impaired" and "Incipient impairment".
  - The severe events partial CCFs and complete CCF make-up about 25% of all MOV events.

Observation time and ICDE events per 5-year period

5-Year period	ICDE events
1980-1985	4
1985-1990	12
1990-1995	71
1995-2000	43
2000-2005	35
2005-2010	6
2010-2015	1
2015-	0
Total	**172**



VII. Lessons learned (2):

Example-1:Motor-Operated Valves CCF (2/3)

- The major observed event causes are
  - "Design, manufacture or construction inadequacy" (31%) and
  - "Internal to component, piece part" (28%).

- About 10% of the events had a CCF root cause related to deficiencies in human actions.

Event Cause	Complete CCF	Partial CCF	Total	Percent
Abnormal environmental stress		1	4	2%
Design, manufacture or construction inadequacy		15	53	**31%**
Human actions, plant staff	3	4	16	9%
Internal to component, piece part		10	49	**28%**
Maintenance		1	7	4%
Procedure inadequacy	6	2	31	18%
State of other component(s)			2	1%
Other			7	4%
Unknown			3	2%
Total	**9**	**33**	**172**	**100%**

VII. Lessons learned (3):

Example-1:Motor-Operated Valves CCF (3/3)

- Deficiencies in the design tend to result in more severe events for MOVs and most problems are caused by electrical I&C design issues.
  - Recurrent control of setpoint and verification of these after test and maintenance have the possibility to reduce the risk of CCF and should be implemented.
- Operator performance errors result in severe events.
  - It is vital to have a well-established safety culture: adequate procedures, written work plans, training of personnel.
- Degradation of components until failure occurs slowly.
  - adequate operational procedures, ageing management and operational actions should be implemented as they have the possibility to prevent events from happening or detect the degradation before complete failure of the component occurs.

VII. Lesson Learned (4):

Example-2: Pre-Initiator Human Failure Events Topical Report (1/2)

Definition

- A pre-initiator HFE (PIHFE) is an event that occurs before a possible accident and is caused by inappropriate actions or human inactions, such as misalignments and miscalibrations.

Observation : Total of 397 PIHFE Events

- 22 % of the ICDE events are Pre-Initiator HFE
- 51 PIHFE events were analyzed. All these events were complete CCFs.
- The most common type of PSF was procedures (76% of the events caused by deficiencies in procedures) followed by training and written work plans.

Pre-initiator human failure events. (Total events in parenthesis.)

Component type	Total	PIHFE % /Component
Battery	10 (77)	14%
Breakers	22 (110)	20%
Centrifugal Pumps	90 (401)	25%
Check valves	10 (117)	9%
Control Rod Drive Assembly	18 (173)	11%
Diesels	60 (242)	26%
Digital I&C	0 (4)	0%
Fans	6 (32)	20%
Heat Exchanger	15 (55)	28%
Inverters	0 (1)	0%
Level measurement	31 (155)	20%
Main Steam Isolation Valves	1 (10)	50%
Motor Operated Valves	48 (173)	30%
Safety and Relief Valves	87 (271)	35%
Total	**397 (1821)**	**22%**

VII. Lesson Learned (5):

Example-2: Topical Report on Pre-Initiator Human Failure Events (2/2)

- **The CCF PIHFEs study shows the importance of:**
  - Quality assurance of procedures. The plant management has an important role to ensure this through training of personnel, QA of processes and safety culture.
  - Adherence to procedures and written work plans in a safe manner. E.g. do not conduct tests in the wrong operational mode or simultaneously.
  - Verification of operability, after maintenance work (installations, modifications and replacements) and after testing (e.g. ensure correct positions of breakers, switches etc.).
  - Adequate training of the personnel involved regarding maintenance and inspections that emphasizes the importance of quality management and safety culture at all organizational levels.

VII. Lesson Learned (6):

Example-3: Topical Report on External Factors Events (1 of 3)

Definition:

- CCF event related to external or environmental factors, or an event directly caused or triggered by such factors (e.g., weather events or conditions external to the plant).

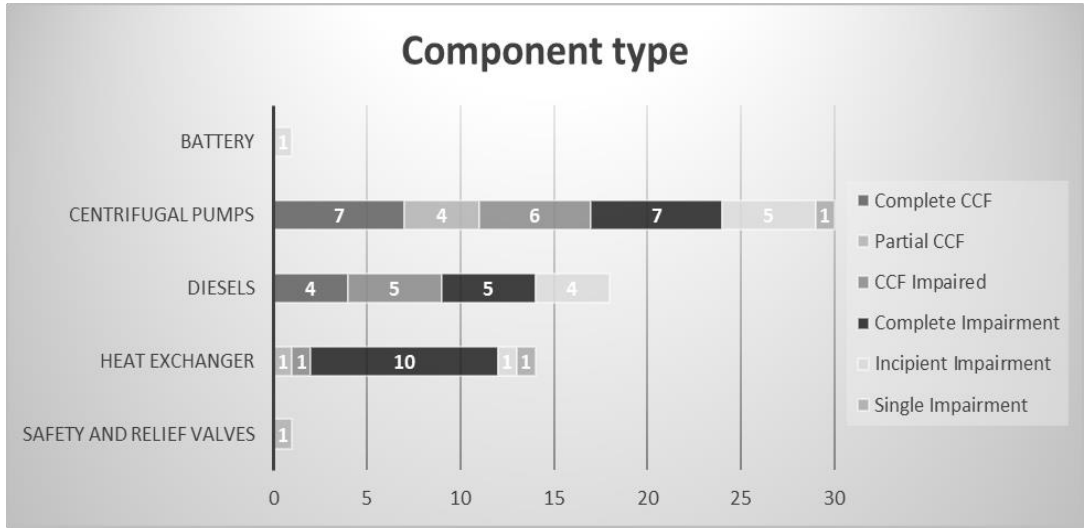
Type of external factors:

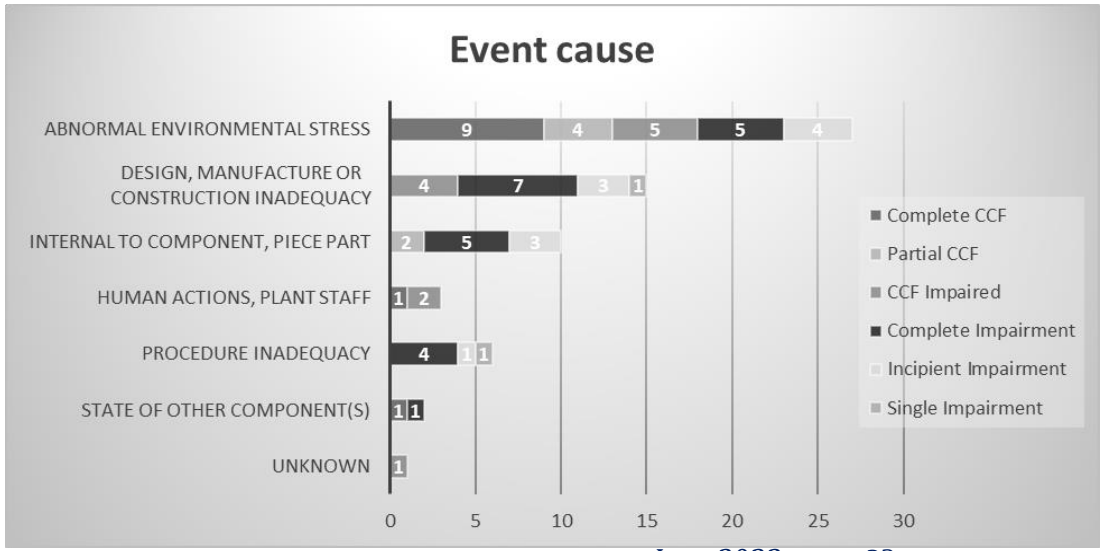
- Two main categories: weather-related events and non-weather events environmental triggers.
- Further sub-division of the events into the following environmental causes was possible:
  - Flooding and hydrological hazards: High/Low seawater/river water level (e.g., low tide); underwater debris (e.g., accumulation of sand causing wear or clogging)
  - Meteorological events: High/Low air temperature (e.g., the build-up of ice plugs); rainfall or snowfall (e.g., block air intake due to heavy snowfall)
  - Biological infestation (e.g., mussels or algae in water intake or airborne particles/pollution, which leads to clogging)
  - Other

VII. Lesson Learned (7):
Example-3: Topical Report on External Factors Events (2 of 3)

Observations

- The analysis covers 64 external factor events.
- Centrifugal pumps are most susceptible to this CCF, followed by Emergency diesel generators (EDG) and Heat exchangers.
- The most common event severity category was “Complete impairment” (34%).
- The relative occurrence of complete CCFs is high, almost a factor two higher compared to the complete ICDE database.
- The major observed event causes are “Abnormal environmental stress” (42%) and “Design, manufacture or construction inadequacy” (23%).
- Causes of Several events with “Abnormal environmental stress” involve debris, algae or mussels causing pumps, heat exchangers or the diesel’s coolers to fail due to clogging.





VII. Lesson Learned (8):
Example-3: Topical Report on External Factors Events (3 of 3)

- Biological infestation is often a slow developing failure mechanism.
  - Importance of adequate procedures for cleaning of strainers, tubes and plates, and to have a backflush capability.
- Hazards related to debris can be avoided in some case with an improved design of strainers.
  - However, sufficient defences to avoid clogging due to heavy debris are difficult to achieve.
- For several events related to degradation due to sand intrusion in the system,
  - monitoring in combination with maintenance and operational practices may result in detection of degradation before failure of the components.
- To mitigate meteorological effects,
  - A careful evaluation of the system design with consideration of operational experience from events triggered or caused by for example freezing effects, blockage of air/ventilation intakes is recommended.

VIII. Conclusion

- **ICDE has changed the views to CCFs a great deal.**
  - CCFs exist, 160 complete CCFs and 267 partial CCFs
  - Deep plant data collection and combining information from many sources, of which a major deal from NPP maintenance databases, needed

- **It is worth forming specialized data exchange projects like ICDE since they can be made to produce useful reports and insights.**
  - National efforts are the key to the success of any project relying on operating experience

- **ICDE has given a birth to several similar types of projects.**
  - OPDE for pipe failure events (on-going under CODAP project)
  - OECD-FIRE for NPP fire events

IX. References

- **More information:**

  Publicly available reports

  - https://projectportal.afconsult.com/ProjectPortal/icde
  - https://www.oecd-nea.org/jcms/pl_25090/international-common-cause-failure-data-exchange-icde-project

X. Summary: ICDE (1994-2022), Milestones and Plans

- Data Exchange (2068 events)
- ICDE operation
  - Phase 7 Summary report 2019, (Phase 8 update 2022)
  - General coding guideline
- Data and publicly available Component reports for
  - Centrifugal Pumps, Diesel Generators, Motor-Operated Valves, Safety Relief Valves, Check Valves, Batteries, Level Measurement, Breakers, Control Rod Drive Assemblies, Heat Exchangers
  - Component reports updates due to extended observation time and exchange, Diesels, Pumps, SRV, MOV
- Issued Topical reports on CCF events
  - External factors (2015, 43 events) (2022 Update, 64 events)
  - Emergency Diesel Generators with all redundant diesels affected (2017, 224 events)
  - Improving Testing (2019, 59 events)
  - Multi-unit events, (2019, 87 multi-unit events)
  - Plant modifications (2019, 54 events)
  - Inter-system dependencies (2020, 25 intersystem events)
  - Pre initiator HFE (2022, 1 events)
- Topical reports under development (2022)
  - Demand event/Interesting event report, SG 50 Workshop,
  - Safety culture, SG 51 Workshop.
- Quantification case reports
  - Batteries,
  - MOV, Pumps, EDG (2022)
  - SG 54 (spring 2022) Workshop on Methods/assumptions
- Candidates (2021-2022) dependent on data exchange
  - Battery component report (Data screening done, on hold)
  - Fans component report (Data screening done)
  - Component reports,
    - MSIV, Digital I&C, Inverters, Cross Component
- Topical reports
  - CCCG definitions in safety analysis of Diversity and DiD level independence

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