The OECD Fire and Pipe Failure Data Exchange Projects

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Abstract:

The goals and organization of the Fire and Pipe Failure Data Exchange projects initiated by the Nuclear Energy Agency (NEA) of the Organization for Economic Co-Operation and Development (OECD) are presented. The Canadian contribution to the projects is discussed and general methodology for data collection and verification are presented. The development of a separate database of Canadian fire events is described. Preliminary comparative component failure statistics generated using this database are presented.

1. Introduction:

The Nuclear Energy Agency (NEA) division of the Organization for Economic Co-Operation and Development (OECD) has initiated two projects for establishing the international exchange of component failure data at nuclear power plants. These are the OECD Fire and OECD Pipe Failure Data Exchange projects, which have as their main goals the identification of component failures leading to fire or pressure boundary failure events, respectively. The primary aim of both projects is to establish an efficient mechanism for feedback of events between all member countries, as well as to amass both qualitative and statistical failure frequency data for application in optimizing Risk Informed In-Service Inspection (RI ISI) schedules as well as improving and validating Probabilistic Safety Assessment (PSA) codes at nuclear power plants.

The goal of this paper is to provide an overview of the current state of the projects in terms of Canadian data collection and verification efforts as well as to present a clear picture of how data collected by the member countries is incorporated into the main international databases. As the OECD Fire data exchange project has been the primary focus thus far in the collection of Canadian data, statistical data presented in this paper is based on fire event data, and not pipe failure event data.

The usefulness of collecting and maintaining Canadian data is highlighted and preliminary comparative statistics developed using Canadian and International data are presented.

2. History:

Each project was founded by the Nuclear Energy Agency (NEA) division of the Organization for Economic Cooperation and Development (OECD), based in Sweden.

The OECD Piping Failure Data Exchange (OPDE) project was initiated in 2000, based on pipe failure event data that had already been collected for Swedish nuclear plants as part of an earlier effort. This previous project, the SKI-Pipe data collection initiative, had been developed by the Swedish Nuclear Power Inspectorate (SKI) in 1994. The project member countries include Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland and the United States.

In 1997, a survey was conducted of OECD member countries with nuclear generating stations to assess the effectiveness of methods being applied in the assessment of fire risk to the plants. The study concluded that a shortage of fire analysis data was a major impediment towards developing quality fire risk assessment programs, recommending the development of an international database to collect and share detailed data on such events amongst member countries. The result was the OECD Fire Event database, which was founded in 2003. Member countries include Canada, Germany, Sweden, France, Spain, Japan, Finland, United States, Czech Republic, and Switzerland.

As of 2006, Canada had joined both projects, but had not submitted any finalized piping failure event or fire event data.

2. Project Structure:

A main international database in either project, containing a compilation of data submitted by the member countries, is maintained by a contracted organization, ES Konsult, based in Sweden. This organization is termed the ‘Operating Agent’ and manages the reception, verification (through interaction with the member country submitting the data), and recording of event data into the international database. Periodically, an updated copy of the full database is delivered to the member countries. Each member country has a representative, termed the ‘National Coordinator’, who is responsible for collecting, verifying (jointly with the Operating Agent) the validity of, and submitting event data to the Operating Agent. In Canada’s case, this is the Canadian Nuclear Safety Commission. See Fig. 1 for a simplified overview of the flow path for the event data, in either project, from the National Coordinator to the Operating Agent. Note that fire data is also collected and managed in an intermediate database maintained by the CNSC and containing additional event data not required by the OECD Fire project, as is discussed in more detail in the next section.

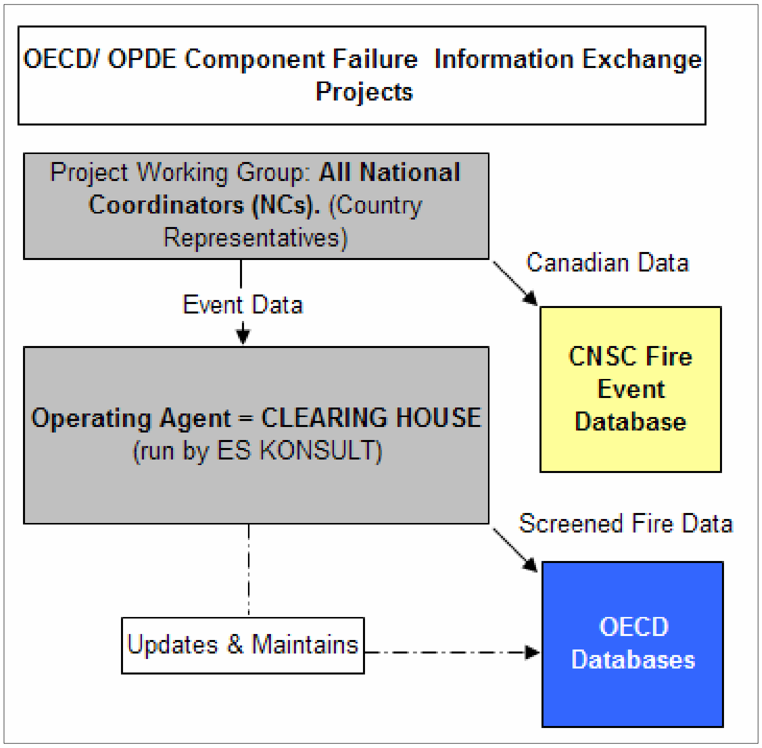


Fig. 1: Simplified flowchart of fire event data from OECD member countries to the main international database. Dataflow to in-house CNSC Fire database also shown.

3. Database Coding Guidelines:

To ensure that all events submitted by the member countries in either project can be integrated into a single database, the details of the events are coded into a set of descriptive fields. In completing each field, the National Coordinator must typically choose from a list of pre-defined values. This binning of parameters into specified values allows the data pertaining to different events and from different countries to be compared on a consistent basis. The fields involved in the description deal with specific aspects of the event, from the general location and event-initiating component in the plant, to the leak rate from the compromised pressure boundary or quantity of material consumed by fire. A summary of the fields used for each project is given in Appendix B.

During the process of collecting fire event data, numerous fields in addition to those outlined by the OECD Coding guideline were found to be useful. The majority of these parameters capture a more detailed analysis of the construction of the building and room in which the fire event took place, as well as more specific fields pertaining to the duration and time of the event. The fields were originally found in the National Fire Protection Association (NFPA) 901 document on reporting fire events. These are listed, along with the standard OECD fields, in Appendix 1.

	OECD Database	OECD + CNSC Database
General Purpose:	Define a framework for multi-national co-operation in fire data collection and analysis.	
		Manage Canadian data.
OPEX:	Establish a mechanism for the efficient feedback of experience.	
Qualitative:	Collect and analyze fire events so as to better understand such events, their causes and their prevention. (Make qualitative conclusions for allocating resources).	
Quantitative:	Record event attributes to facilitate quantification of fire frequencies and fire risk analysis (Probabilistic Safety Analysis).	
		Include details on building structure. (ex. structure height, number of stories, floor area..)
		Expanded important event times section. (ex. report time, en route time, blackout time..)

Fig. 2: Overview of fields added to CNSC database from base OECD dataset

The addition of the NFPA 901 fields to the definition criteria for each fire event resulted in the development of an in-house database to store the combined OECD + NFPA dataset, since the OECD database alone would not capture the desired fields. The database was designed to be able to produce just the OECD subset of the total fields for facilitated submission of the event data to the Operating Agent. Fig. 2 provides a summary of the additional goals of the in-house CNSC fire database. Fig. 3 illustrates the CNSC fire event database and the subset of the data which is sent to the OECD.

Additionally, the establishment of an in-house fire event database facilitates management of Canadian data and allows the computation of fire event frequencies at Canadian nuclear power plants. The CNSC fire event database has a built-in frequency calculator which computes the rate of occurrence of fire events at each Canadian nuclear plant in events per year per reactor. Other useful statistics can be generated using the data stored in the CNSC database, and basic comparative plots with international data, discussed in the next section, are given in the Appendix A.

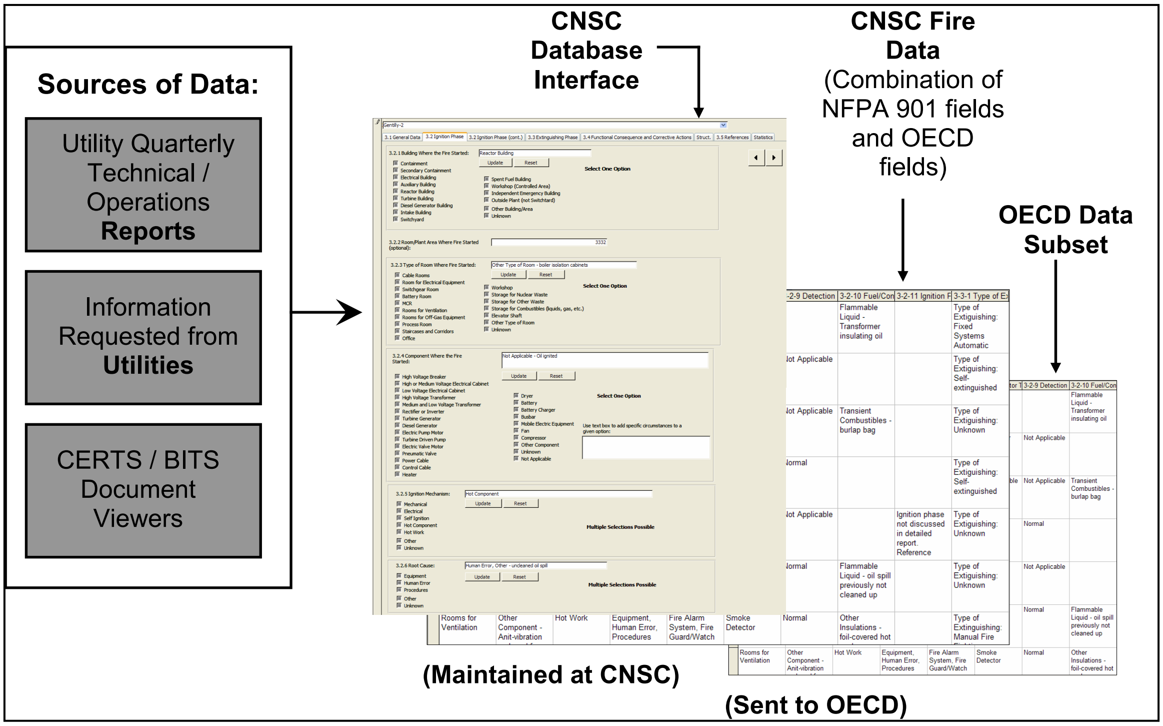


Fig. 3: Illustration of the expanded dataset used in the in-house CNSC Fire database

The identification of previously unanticipated component failures modes using the international databases for either project can be used to improve the probabilistic safety analysis (PSA) codes used at Canadian nuclear power plants. The databases can also be used to provide estimates on the frequency of occurrence of pipe breaks or fire events for various plant components, which can be applied in devising appropriate risk-informed in-service inspection (RI-ISI) schedules. Fig. 4 shows a typical PSA table used in computing the risk of a large radioactive release from a plant based on the individual risks of failure of a series of plant components. Data from the OECD fire and OPDE projects could identify new initiating events (event 'A') which were not accounted for, as well as improving the estimates of the various component failure frequencies used in the analysis (P_A, P_B, P_C, P_D, P_E).

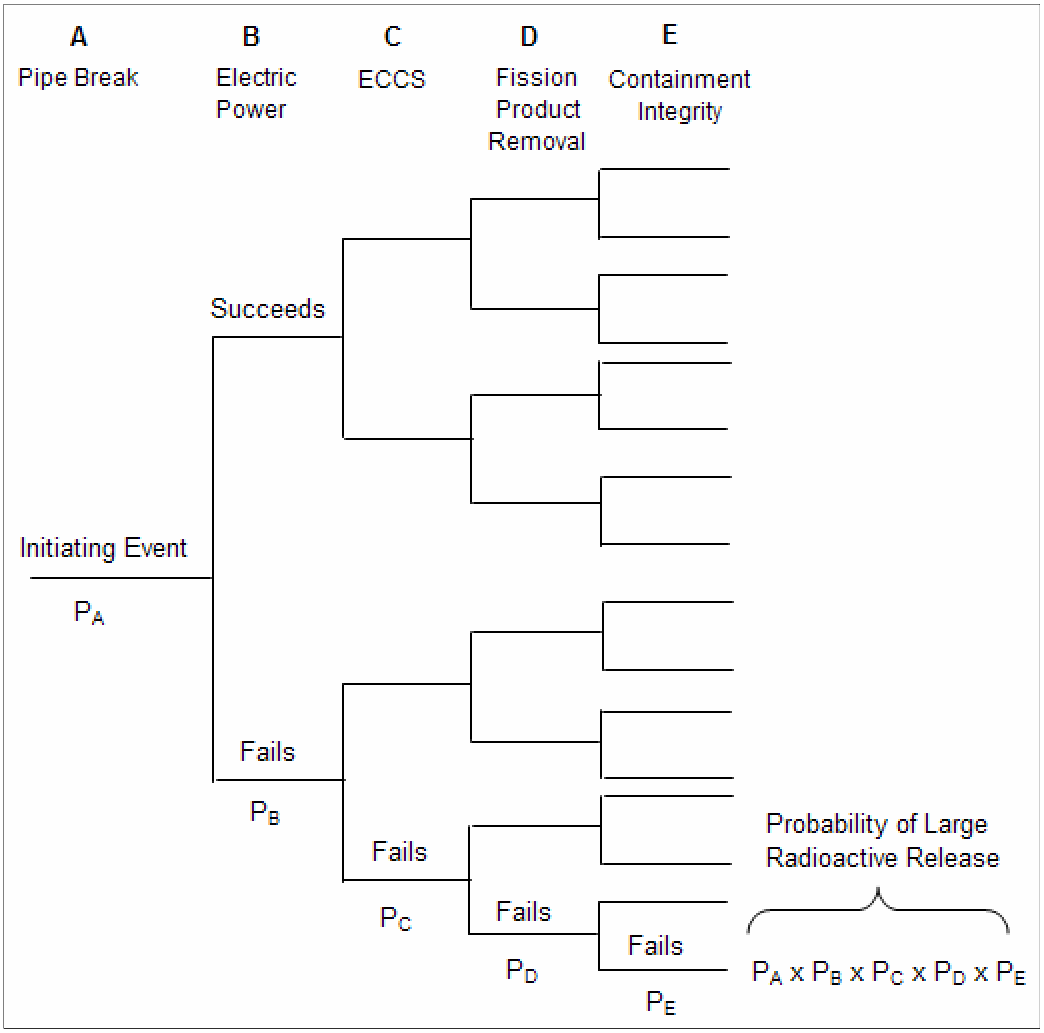


Fig. 4: Partially-filled PSA diagram showing derivation of the probability of a large radioactive release as a result of various precursor factors. Component failure frequency data obtained from the OECD projects can be used to improve the data used on these trees

4. Preliminary Comparative Statistics Generated from Canadian Data

The criteria for defining a fire event used in collecting the Canadian data up to this point in the collection process has been intentionally non-restrictive, essentially including any fires or scenarios from which a fire could have been started, such as smoldering insulation material or melted electrical components. This was to accommodate the objectives of the in-house CNSC fire database, which was intended to keep a record of all fire events, as well as all those events which had the potential to become fires, since the latter is useful in identifying plant areas and components where the risk of fire is relatively high.

In comparing the frequency data for the occurrence of fires based on various key fields between Canadian and International collections, it was necessary to first ensure that a common reporting threshold was applied to each set of data. According to the 2005 OECD Fire Project Coding Guidelines [1], the reporting threshold of each member country varies according to their respective national guidelines. As such the OECD Fire database is designed to record the thresholds for each country for reference purposes. However, it is likely that statistics generated in the 2005 OECD Fire presentation [5] used all available data in the database up to that point in time, regardless of the various thresholds affecting the data. Therefore, it is believed that a comparison between the international fire event statistics given in [5] and the current Canadian data is essentially valid and provides a useful means of benchmarking the Canadian statistics with those of the other member countries. These comparative fire event statistics for several specific fields in the OECD Coding guideline are presented in Appendix 1.

5. Interpretation of the statistics:

Component where Fire Started (Fig. A1):

The ‘other’ specification for ‘component where fire started’ field is markedly higher (36%) for Canadian data than it is for the International data. This can be explained in that the OECD presentation [5], on which the international statistics in this paper are based, uses only a subset of the full set of options found in the Coding Guideline for the ‘component where fire started’ field. It is likely that only those fields with the highest occurrences in the international data were included in the presentation. As such, for many events in the International data, this field was essentially omitted in determining the percentages for each option.

In order to perform a meaningful comparison, this same limited number of fields was used in categorizing the Canadian data. The high number of Canadian fire events classified as ‘others’ for this field is a result of these events being binned as ‘others’ in light of a more appropriate option not being present in the subset used. While the frequency of these options in the international data was likely deemed too low for inclusion in their presentation, the similar Canadian data was instead grouped under ‘others’, rather than being discarded.

Fig. A2 shows a revised plot of the comparative data for this field, in which Canadian data previously binned as ‘others’, but for which there existed a more appropriate selection in the full option set provided in the OECD Coding Guideline, was omitted in the determination of the percentages. As well, minor fires such as those occurring in waste paper receptacles and ash cans (which had previously been binned as ‘others’) were similarly excluded from the comparison. As can be seen in the figure, while the ‘others’ category is reduced compared with Fig. A1, it remains much higher than seen for the international data. This is perhaps indicative of a difference in the reporting thresholds used for the two sets of data, as the Canadian data likely includes more minor events such as fires in cars, common rooms and other non-process related plant areas, which may have been excluded in the international data.

Conversely, the elevated incidence of fires originating from ‘electric motors’ seen in the Canadian data appears to arise from a legitimate difference between the two datasets. This is a trend which could require investigation into these components in Canadian nuclear plants, and is potentially a good example of the value of participating in international statistical ‘benchmarking’ to identify high-risk plant areas.

<u>Ignition Mechanism (Fig. A3):</u>

As shown in Fig. A3, the rate of occurrence of particular ignition mechanisms is very consistent with international standards. The higher ‘Mechanical’ ignition mechanism for Canada might be explained by the fact that events involving electric motors with no ignition mechanism specified were typically binned as ‘Mechanical’. Alternatively, Canadian plants may indeed have a greater proportion of mechanically-ignited incidents than that which is seen worldwide. The greater proportion of self-ignited fire events seen in the international data (7.48% for international data vs. 1.65% for Canadian data) appears to be a legitimate difference between the two datasets. Interestingly, according to the OECD coding guidelines, this category is only for events started by auto-oxidation of oil in insulation.

<u>Exinguishing System Type and Performance (Fig. A4 & A5):</u>

Figures A4 and A5, comparing the type and performance of the system used to extinguish the fire respectively, show a close agreement between Canadian and International data.

<u>Fire Successfully Extinguished the Fire (Fig. A6):</u>

As shown in Fig. A6, Canada has the same primary extinguishing measure as the other OECD member countries (on-site fire brigade). The lower percentage for this category seen in the international data could be due to not all plants having on-site fire brigades. The difference in proportion for other fields between International and Canadian data could be related to this as well; for example, the category for 'Shift Personnel', who act in place of an on-site fire brigade in some countries, is more than 3 times higher for international plants than for Canadian plants, tending to explain the resulting lower ‘on-site fire brigade’ incidence for those countries.

<u>Fire Detection Type (Fig. A7):</u>

The Canadian data shows the same top two types of detection as does the international data; see Fig. A7. Additionally, Canadian plants show a larger proportion of ‘Other Plant Personnel’ detections and lower proportion of ‘Fire Alarm System’ (automatic system detections) than the OECD statistics. This might be explained if it is assumed that Canada has more minor events reported which may not have been severe enough to trigger a fire alarm detection system, and were instead noticed by personnel.

Alternatively, it could be indicative of a deficiency in detector coverage per floor area relative to other types of plants.

6. Conclusion:

The OECD fire event and OPDE data exchange projects are important tools in the identification and quantification of high-risk components with regard to fires and pipe breaks, respectively. The results can be practically applied toward improving RI-ISI schedules as well as toward refining PSA codes used at nuclear power plants. Additionally, the establishment of an in-house CNSC database for managing Canadian fire events allows the use of a custom set of parameters in describing the events, from which an OECD-compatible subset can be produced.

The comparative fire event statistics generated using International data and preliminary Canadian data are generally in close agreement, suggesting that nuclear plants in Canada are operating with similar risk of component fires as those seen worldwide, underscoring the value of participating in such international data exchange projects, since the data will likely be applicable to Canadian plants.

REFERENCES

1. Angner A., OECD-Fire Coding Guideline (OECD-FIRE-PR02), December 2005

2. Colligan A., Lojk R., Riznic J., 2004, "The OECD Pipe Failure Data Exchange Project – Data Validation on Canadian plants", *Proceedings of the 12th International Conference on NuclearEngineering*

3. McCormick, Norman J., 1981 *Reliability and Risk Analysis, Methods and Nuclear Power Applications*, Academic Press, New York.

4. NFPA 901 Standard Classifications for Incident Reporting (2006)

5. Roewekamp, Marina, Werner, W., Angner A., Mathet E., "A Framework for International Cooperation in Fire Data Collection and Analysis, Preliminary Insights from Data Collected", *International Workshop on Fire Probabilistic Safety Assessment*, *Puerto Vallarta, Mexico, May 23-26, 2005*

APPENDIX A

Preliminary Comparative Fire Event Statistics

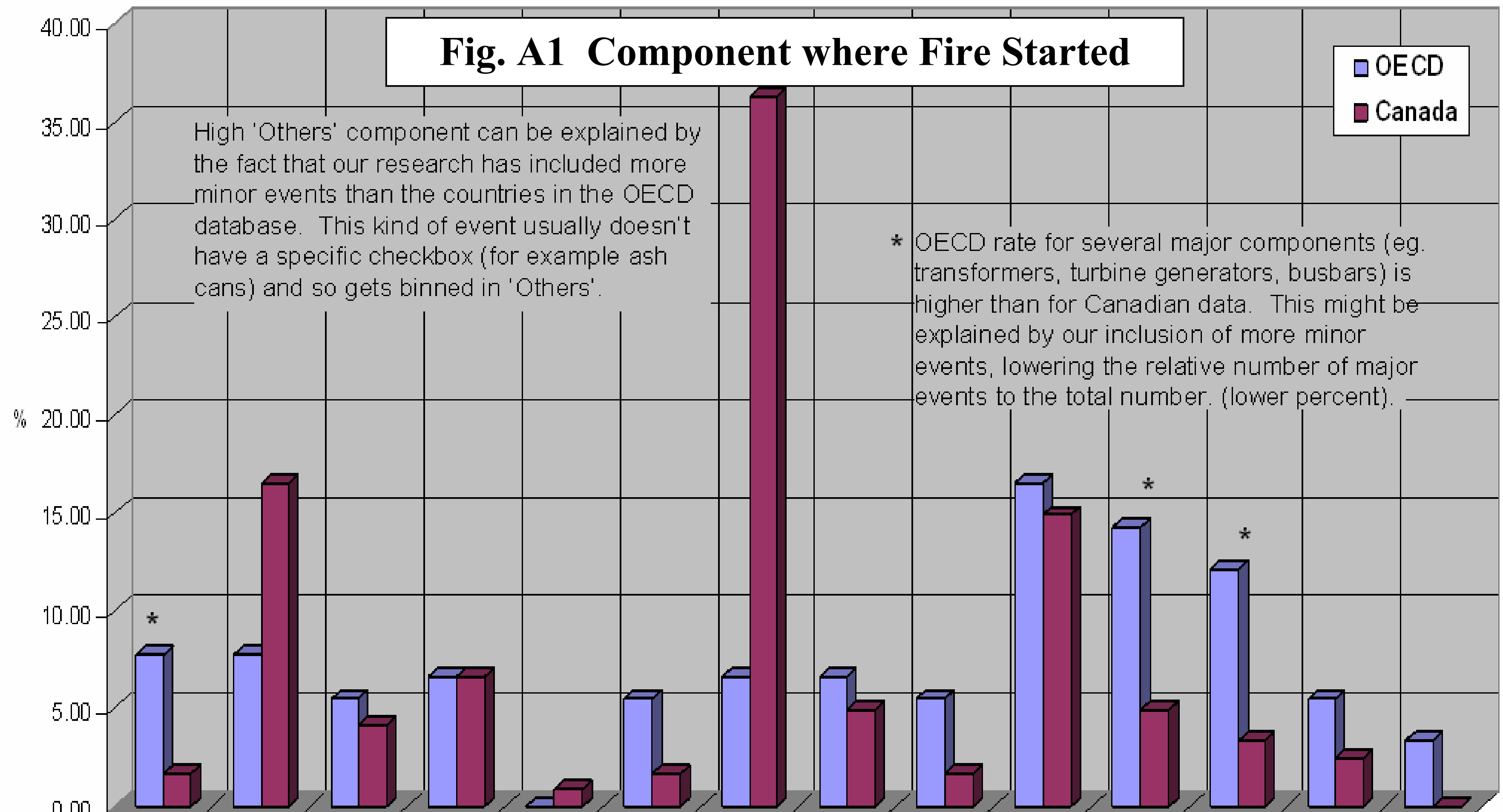
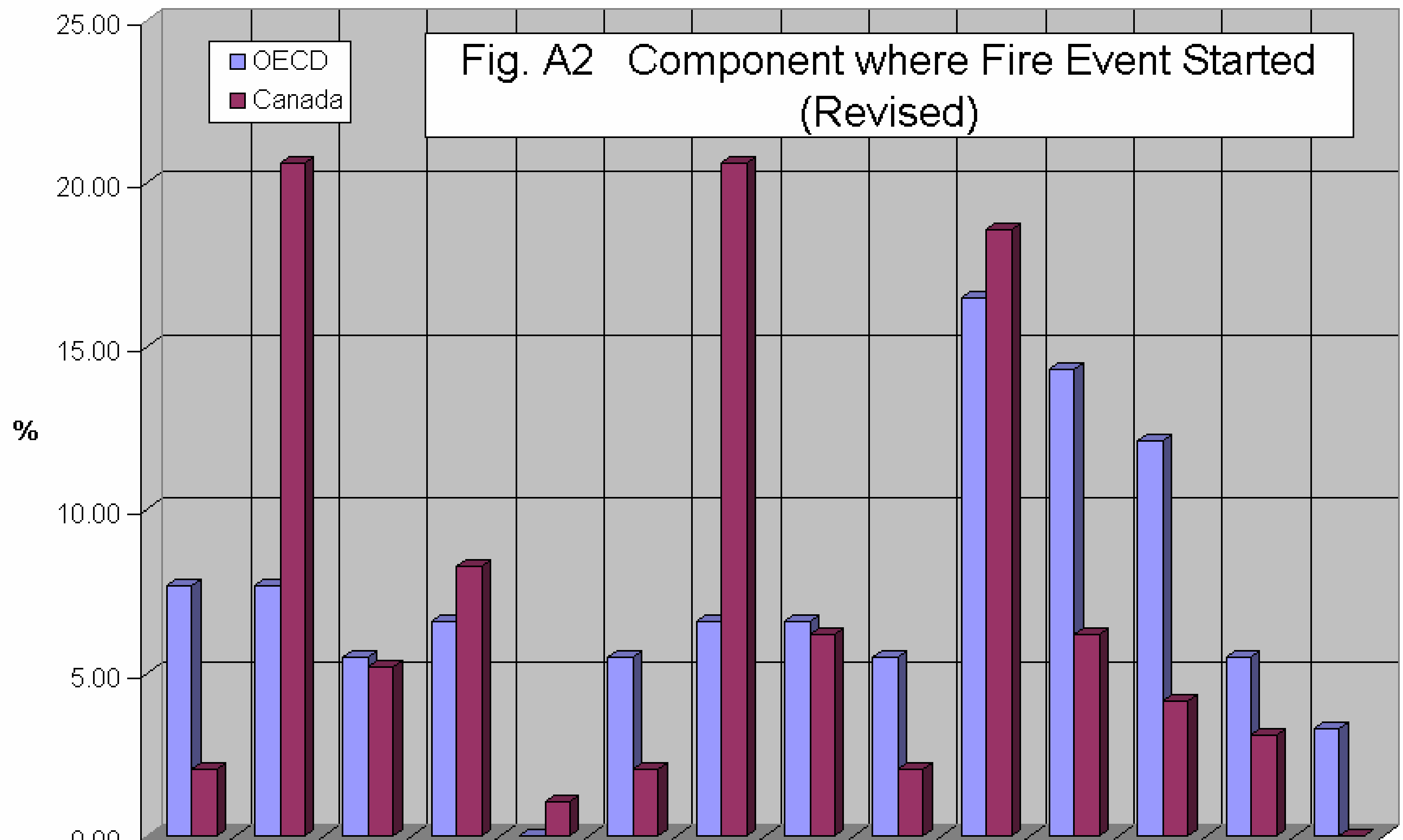


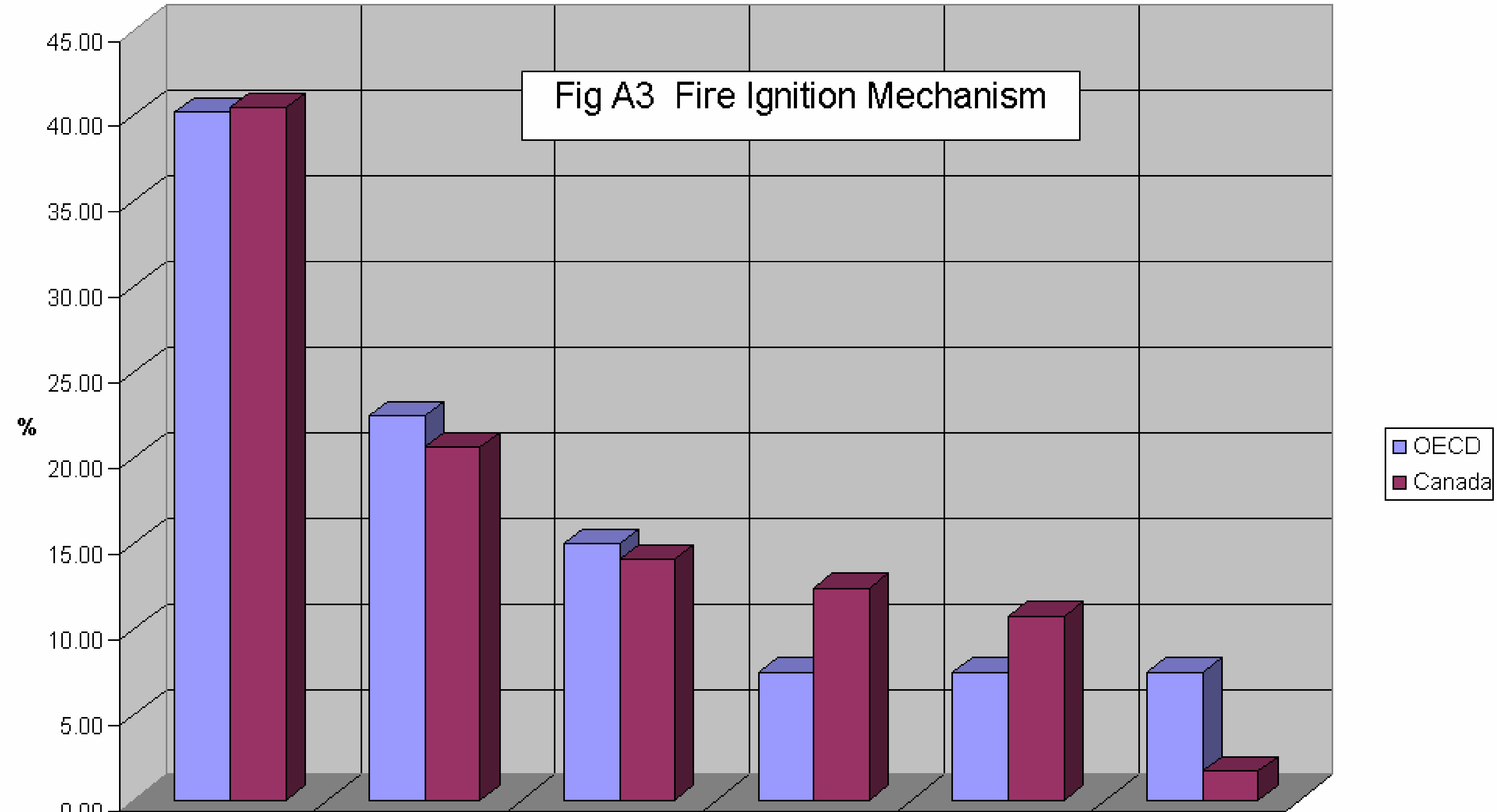
Fig. A1 Component where Fire Started

	Busbar	Electric Motor	Heater	Hi / Med. Volt. Elect.Cab.	High Volt. Breaker	Low Volt. Elect. Cab.	Others	Power Cable	Rectifier / Inverter	Struct. + comp.w/ hot work	Transf.	T/G	Valves	Oil Sep.
OECD	7.69	7.69	5.49	6.59	0.00	5.49	6.59	6.59	5.49	16.48	14.29	12.09	5.49	3.30
Canada	1.65	16.53	4.13	6.61	0.83	1.65	36.36	4.96	1.65	14.88	4.96	3.31	2.48	0.00

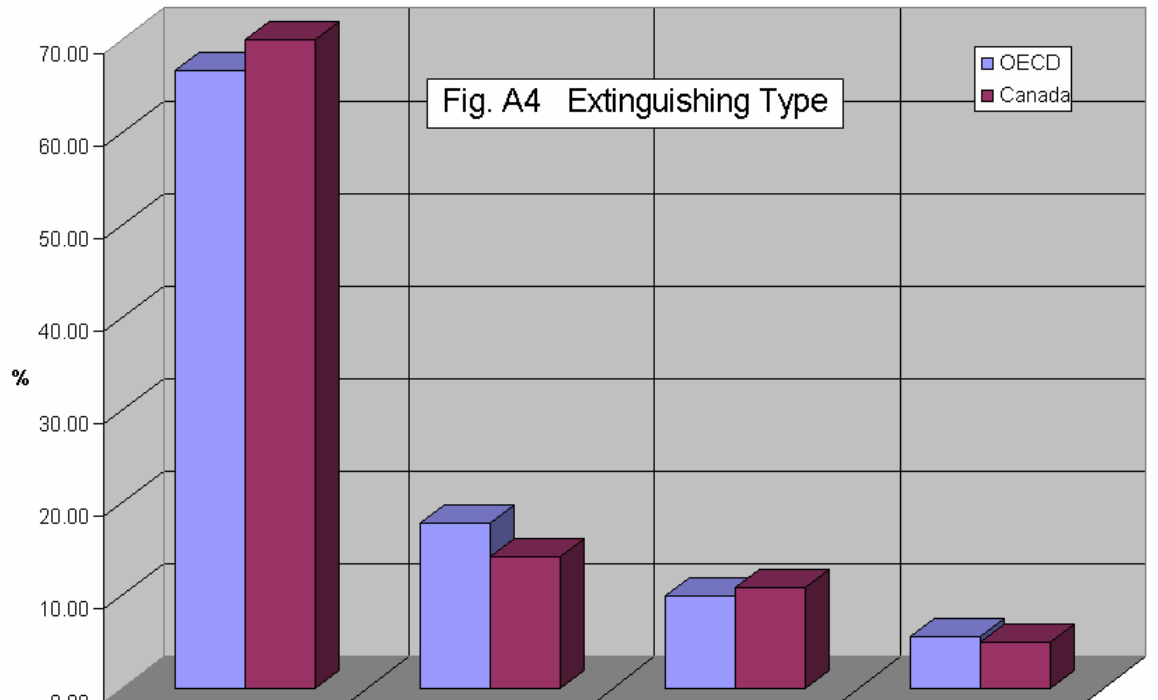


	Busbar	Electric Motor	Heater	Hi / Med. Volt. Elect.Cab	High Volt. Breaker	Low Volt. Elect. Cab.	Others	Power Cable	Rectifier / Inverter	Struct. + comp.w/ hot work	Transf.	T/G	Valves	Oil Sep.
OECD	7.69	7.69	5.49	6.59	0.00	5.49	6.59	6.59	5.49	16.48	14.29	12.09	5.49	3.30
Canada	2.06	20.62	5.15	8.25	1.03	2.06	20.62	6.19	2.06	18.56	6.19	4.12	3.09	0.00

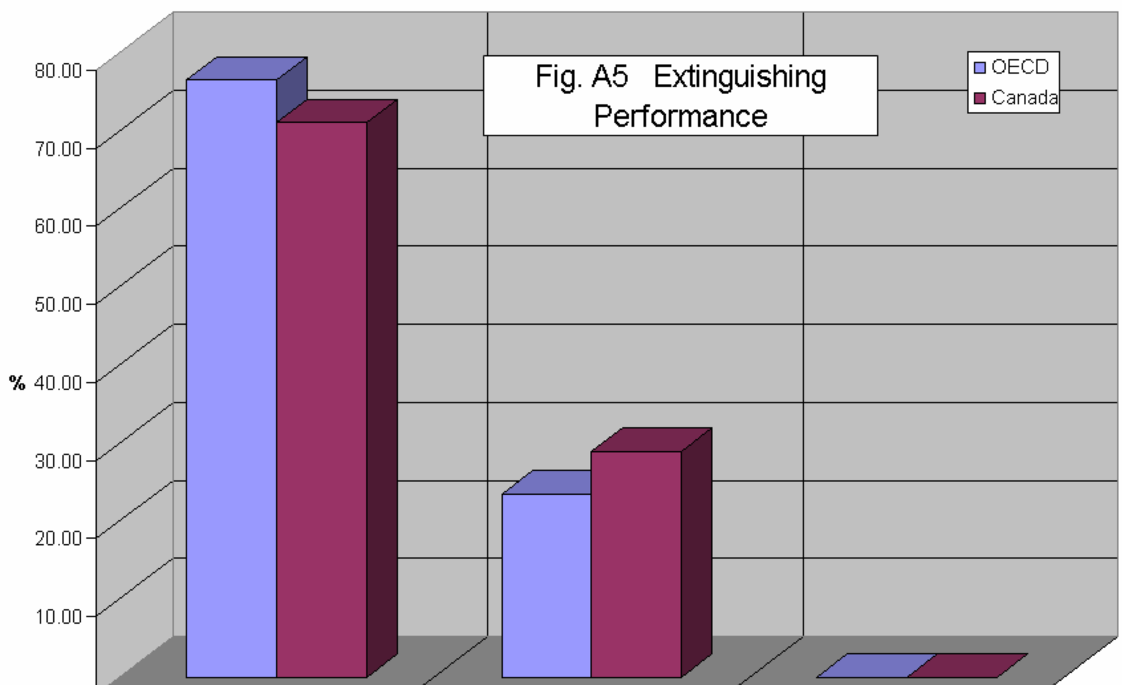
Component



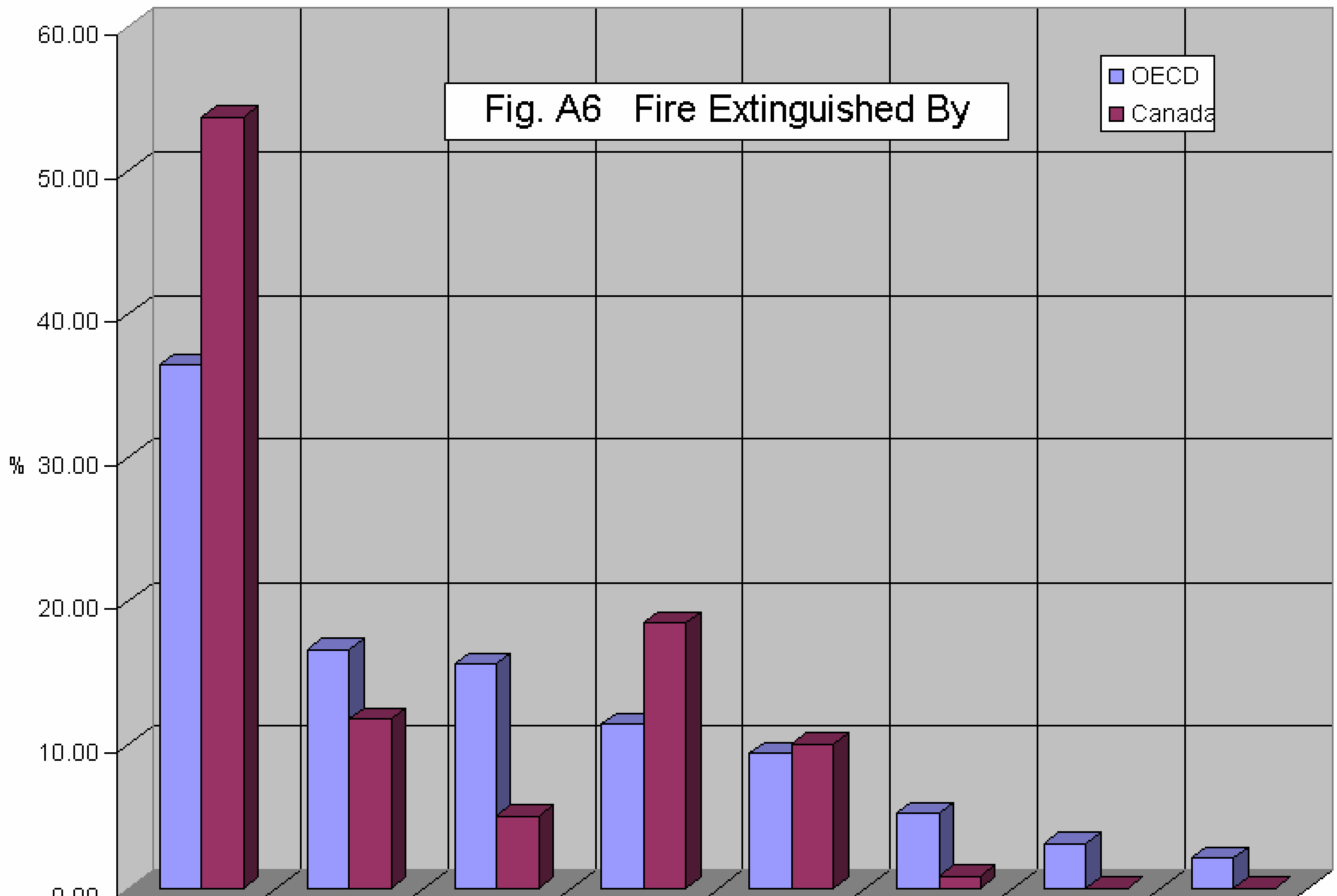
	Electrical	Hot Component	Hot Work	Mechanical	Other	Self Ignition
OECD	40.19	22.43	14.95	7.48	7.48	7.48
Canada	40.50	20.66	14.05	12.40	10.74	1.65



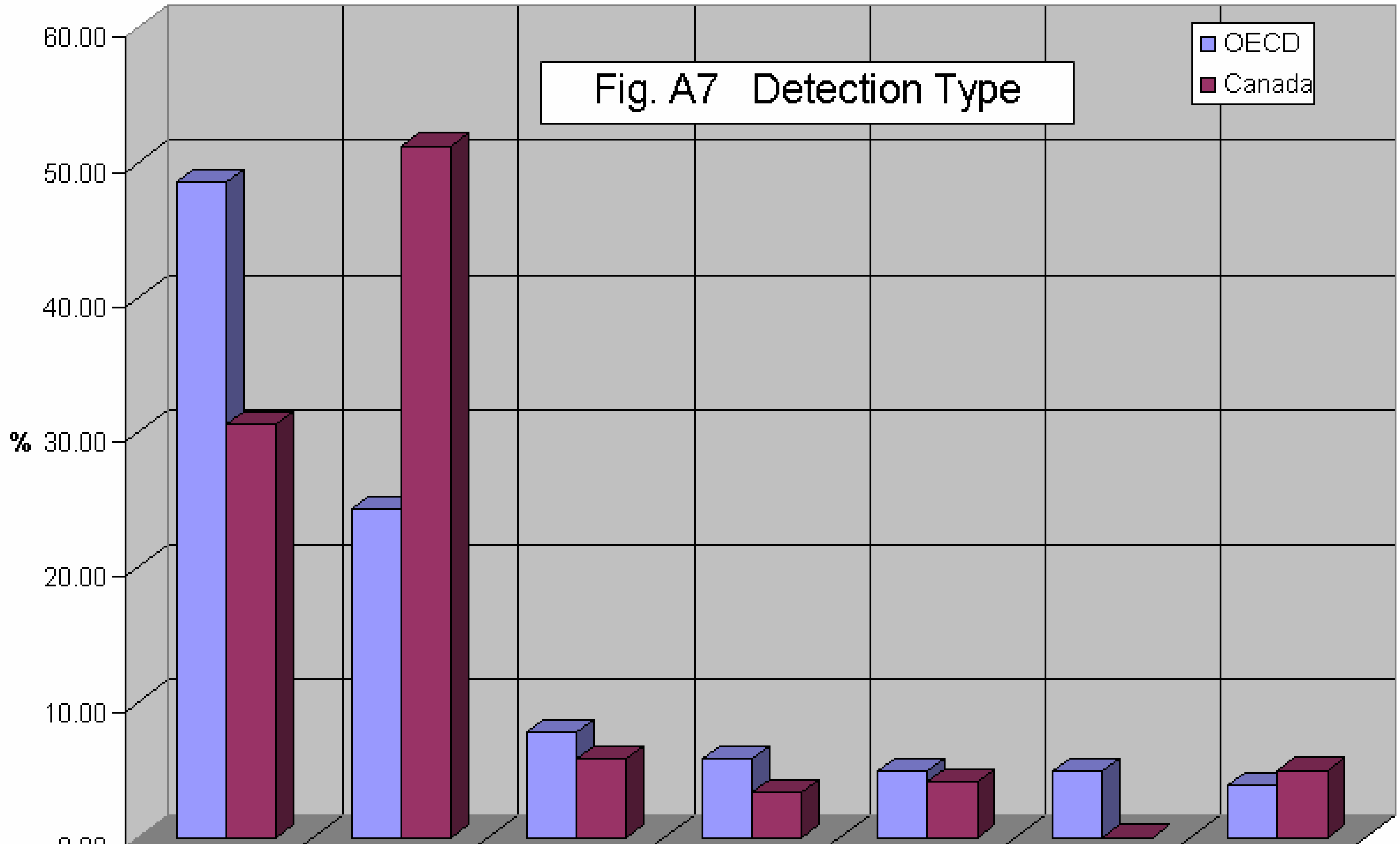
	Manual Fire Fighting	Self Extinguished	Isolation of Fire Source	Manual Fire Fighting + Fixed System
OECD	66.67	17.78	10.00	5.56
Canada	70.00	14.17	10.83	5.00



	Normal (Auto Ext. worked)	Not Applicable (Human Ext.)	Malfunction (Auto Ext. fail)
OECD	76.47	23.53	0.00
Canada	71.07	28.93	0.00



	Local On-Site Fire Brigade	Self Extinguished	Shift Personnel	People in the Area	Personnel + Local/Ext Brigades	Fixed Extinguishing System	External Fire Brigade	Shift Personnel + Fixed System
OECD	36.46	16.67	15.63	11.46	9.38	5.21	3.13	2.08
Canada	53.78	11.76	5.04	18.49	10.08	0.84	0.00	0.00



	Fire Alarm System	Other Plant Personnel	Plant Walk Down	Other	Indirect Signal	Fire Alarm System + Indirect Signal	Fire Guard / Watch
OECD	48.54	24.27	7.77	5.83	4.85	4.85	3.88
Canada	30.58	51.24	5.79	3.31	4.13	0.00	4.96

APPENDIX B

Summary of Event Fields

Fire Event Descriptive Fields

3-1-1 Event Title	Descriptive title, show nuclear safety implication
3-1-2 Plant	Requires correspondence table
severity	severity level to event (1 to 3)
3-1-3 Registrar	Name of initial creator of OECD FIRE event record
3-1-4 Date and Time of Detection	YYYY-MM-DD HH:MM
year	takes year portion of date
3-1-5 Date of OECD FIRE Event Detection	YYYY-MM-DD
3-1-6 Date of OECD FIRE Event Revision	YYYY-MM-DD, cause of revision
3-1-7 OECD FIRE Event Description	See coding guideline for required details
3-1-8 Sequence of Events	Structured record of event in bullet form with times and events
3-1-9 Event Interpretation	Clarifications, applicability to other operational modes (optional), safety
3-1-10 Operational Mode Prior to the Event	Choose from list, if 'Shutdown mode', specify sub-mode in text box
3-1-11 Confirmation Time	HH:MM, Time interval between time of detection/ time of confirmation
3-1-11 Confirmation Time Clarification	Event Specific Definition of "Confirmation Time" (Optional)
3-1-12 Suppression Time	HH:MM: Duration of Suppression Efforts
3-1-12 Suppression Time Clarification	Event Specific Definition of "Suppression Time" (Optional)
3-2-1 Building Where Fire Started	Choose from list, if 'other', specify in text box
3-2-2 Room/Plant Area Where Fire Started (optional)	Use plant code for room if possible
3-2-3 Type of Room Where Fire Started	Choose from list, if 'other' specify in text box
3-2-4 Component Where the Fire Started	Choose from list, if 'other' specify in text box
3-2-5 Ignition Mechanism	Select applicable fields, if 'other' specify in text box
3-2-6 Root Cause	Select applicable fields, if 'other' specify in text box
3-2-7 Type of Fire Detection	Select applicable fields
3-2-8 Detector Type	Select applicable fields
3-2-9 Detection System Performance	Choose from list
3-2-10 Fuel/Combustibles/Fire loads	Select applicable fields, if 'other' specify in text box
3-2-11 Ignition Phase Comments	Reflections made, clarification of coding
3-3-1 Type of Extinguishing	Select applicable fields, if 'other' specify in text box
3-3-2 Fire Extinguishing System Performance	Choose from list
3-3-3 Who Successfully Extinguished the Fire	Select applicable fields, if known specify number in text box
3-3-4 Manual Fire Fighting Performance	Choose from list
3-3-5 Extinguish Phase Comments	Reflections made, clarification of coding
3-4-1 Operational Mode Due to Fire	Choose from list, if 'Shutdown mode', specify sub-mode in narrative box
3-4-2 Heat or Hot Gases Influence	Choose from list
3-4-3 Smoke Influence	Choose from list, if 'Smoke Influence', elaborate in narrative box
3-4-4 Secondary Effects	Choose from list
3-4-5 Corrective Actions	Choose from list
3-4-6 Comments on Consequence and Corrective Actic	Reflections made, clarification of coding
3-5-1 References	See Coding Guideline document for information
3-6 Relevance Index	Assigned Jointly by NC and OA

Additional Time Fields Added from NFPA 901 Document (for Fire Events):

5-7-5-1 Event Start Time	Text	time of ignition or start of event
5-7-5-2 Discovery Time	Text	moment at which a person senses the danger or incident / automatic detector closes its contacts
5-7-5-3 Report Time	Text	time at which dispatch or alarm center responsible for dispatching fire department resources first learns of fire or incident
5-7-5-4 Dispatch Time	Text	time at which a fire service resource is notified to respond to an alarm
5-7-5-5 En Route Time	Text	time at which resource or apparatus with crew aboard starts its response to the incident
5-7-5-6 Arrival Time	Text	time at which unit arrives at the scene of the incident
5-7-5-7 First Action Time	Text	time at which control activities begin
5-7-5-8 Agent Application Time	Text	moment at which the extinguishing agent first contacts the flames
5-7-5-9 Containment Time	Text	time at which control lines or natural barriers surround a fire or fire spread is checked
5-7-5-10 Control Time	Text	time at which fire is sufficiently surrounded and quenched that, in judgment of cmd.officer, no longer threatens further spread / destruction of property
5-7-5-11 Blackout Time	Text	time at which there is no open flame or glow of burned material. Also referred to as 'fire out' time
5-7-5-12 Scene Release Time	Text	time at which all actions of fire service have ceased and scene has been released to property owner
5-7-5-13 Resource In-Service T	Text	time at which a specific resource is again ready to respond to an alarm

Other Fields Added-

severity	Number	severity level to event (1 to 3)	Used by Event Frequency Calculator
year	Number	takes year portion of date	Used in Calculations
Station Report Number	Text		Added for Convienience

Additional Building Structure Fields Added from NFPA 901 Document:

7-4-1 Type of Construction	Text
7-4-2 Method of Construction	Text
7-4-3 Year of Construction or Total Renovation	Number
7-4-4 Structure Height or Depth	Number
7-4-5 Number of Stories	Number
7-4-6 Floor Area	Number
7-4-7 Manufactured Home or Industrialized Unit Identification	Memo
7-4-8 Structure Type	Text
7-4-9 Property Value	Number
7-4-10 Structure Status	Text
7-5-1 Number of Occupants	Number
7-5-2 Age and Ability of Occupants	Text
7-6-1 Protection of Stairways and Vertical Shafts	Text
7-6-2 Interior Finish	Text
7-6-3 Interior Finish Substrate or Solid Supporting Material	Text
7-6-4 Finish on Substrate or Solid Supporting Material	Text
7-7-1 Protection of Floor Openings	Text
7-7-2 Protection of Openings in Horizontal Barriers	Text
7-8 Roof Covering	Text
7-9 External Exposure	Text
7-10 Perimeter Access	Text
7-11 Electrical Service Quality	Text
7-12 Heating Service Quality	Text
7-13 Control of Smoking Practices	Text

7-4-10 Structure Status	Text
7-5-1 Number of Occupants	Number
7-5-2 Age and Ability of Occupants	Text
7-6-1 Protection of Stairways and Vertical Shafts	Text
7-6-2 Interior Finish	Text
7-6-3 Interior Finish Substrate or Solid Supporting Material	Text
7-6-4 Finish on Substrate or Solid Supporting Material	Text
7-7-1 Protection of Floor Openings	Text
7-7-2 Protection of Openings in Horizontal Barriers	Text
7-8 Roof Covering	Text
7-9 External Exposure	Text
7-10 Perimeter Access	Text
7-11 Electrical Service Quality	Text
7-12 Heating Service Quality	Text
7-13 Control of Smoking Practices	Text
7-14-1 Solid Kindling Fuels	Text
7-14-2 Flammable or Combustible Liquid Use	Text
7-15 Obstacles to Rescue and Fire Control	Text

(The descriptions for these fields are either fairly self-explanatory, or very long – see NFPA 901 Section 7 (attached), or database Main View, tab ‘Structure’ for more details).

Pipe Break Event Descriptive Fields

Event Date
Completeness Index
Multiple Events Reports
Plant Name:
Event Type
Plant Operational State
Corrective Action
TTR
TTR Class
Leak Rate Class
System
Code Class
Piping Component
Bi-Metallic Weld
Diameter Class
Wall Thickness
Material
Design Pressure
Process Medium
Failure Attributed to ISI Program Deficiency
Photograph(s) / Illustration(s)
Appparent Cause
Underlying Cause -1
Underlying Cause -2

Flaw Description
Multiple Circumferential Flaws
Number of Circumferential Flaws
Crack Depth [%]
Axial Length (mm)
Ratio of Crack Length to Circumference
Aspect Ratio
Event Category
Impact on Plant Production
Collateral Damage
Quantity Released
System Group
Weld Configuration
Diameter
Pipe Schedule
Material Designation
Design Temp
Estimated Component Age
Plant Location
Method of Detection
Method of Fabrication
Location of Failure
Root Cause Analysis
ISI History